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JOURNAL OF ELECTRICITY

POWER AND GAS

Devoted to the Conversion, Transmission and Distribution of Energy

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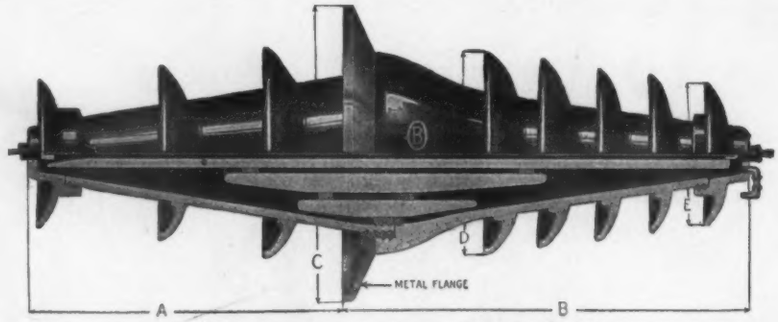

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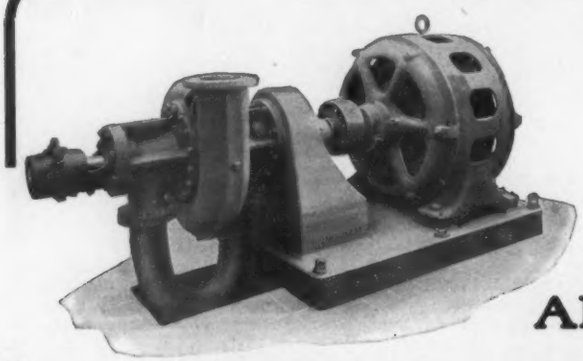

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POWER AND GAS
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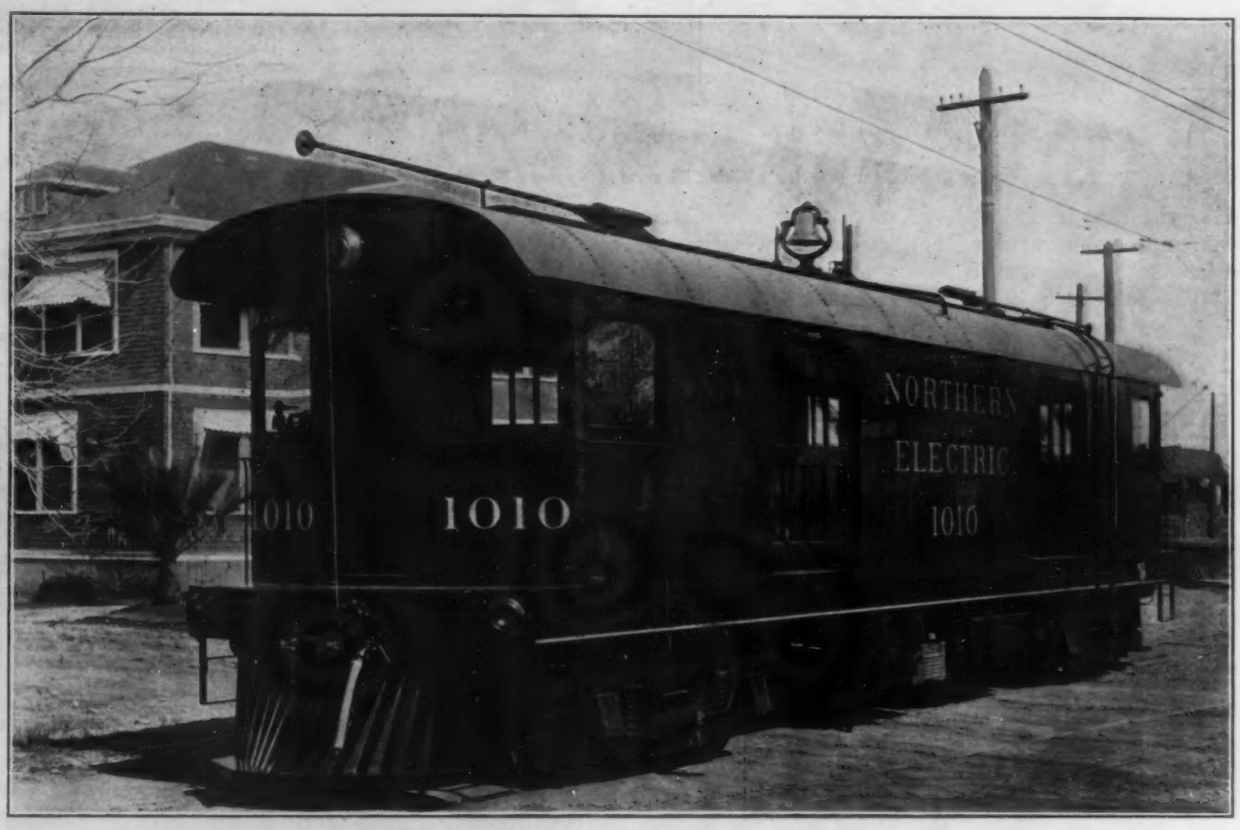
TRAIN DESPATCHING ON THE NORTHERN ELECTRIC

BY L. H. BALDWIN.

Another step in the advancement of electrical appliances in the operation of railroads, and one of special interest to those using electricity as a motive power has just been demonstrated with the completion of the telephone despatching system for the handling of trains on the Northern Electric Railroad in California.

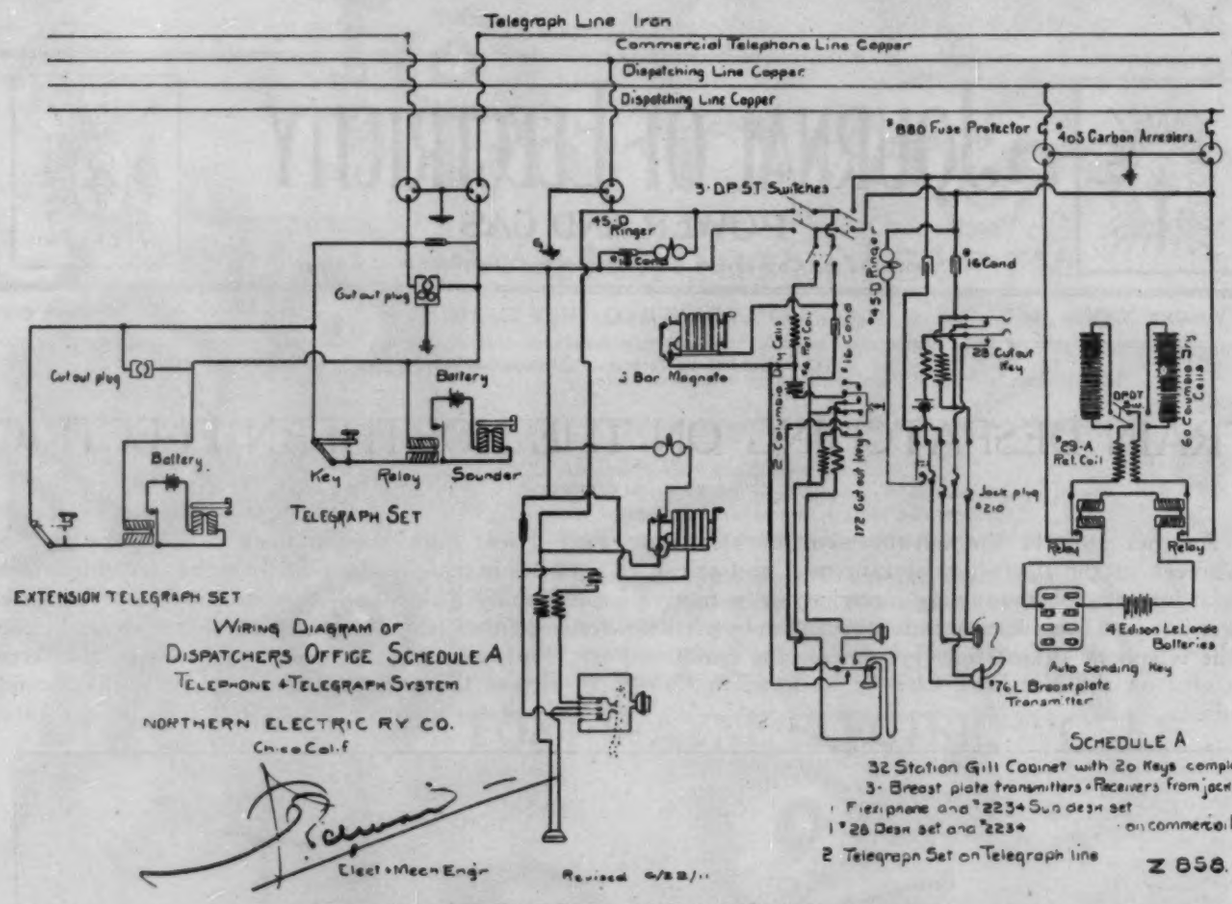


Electric Locomotive and Despatcher's Office.

This railroad operates between Sacramento, Chico and Oroville in the central part of the State. Its trackage covers approximately one hundred miles of roadbed and is operated by the third rail system employing six hundred volts d.c. supplied through substations distributed at intervals along the right of way. The primary current supplying these substations ranges from twenty-two hundred to sixty thousand volts a.c. These high tension lines parallel the railroad for miles in many instances. It is the fact of operating successfully a telephone system with induction interference either from these high tension lines or the electric third rail that makes its success of special interest.

It was through the careful study of these conditions and the untiring efforts of Mr. J. P. Edwards, the electrical and mechanical engineer of the railroad, that the line was so constructed to entirely overcome any electrical disturbances arising therefrom. The excellent result obtained can be realized from the fact that the line is so quiet that the tick of a watch can be heard over its entire length.

Three distinct ways of communication have been provided; a despatcher's circuit for despatching trains,



Despatcher's Wiring Diagram of Northern Electric Company

a straight magneto telephone circuit for commercial work, and a Morse telegraph circuit for emergency work.

The telegraph instruments are looped from one side of the commercial circuit, a one microforad condenser being bridged across the loop at each station

J. P. EDWARDS, Electrical and Mechanical Engineer in Charge

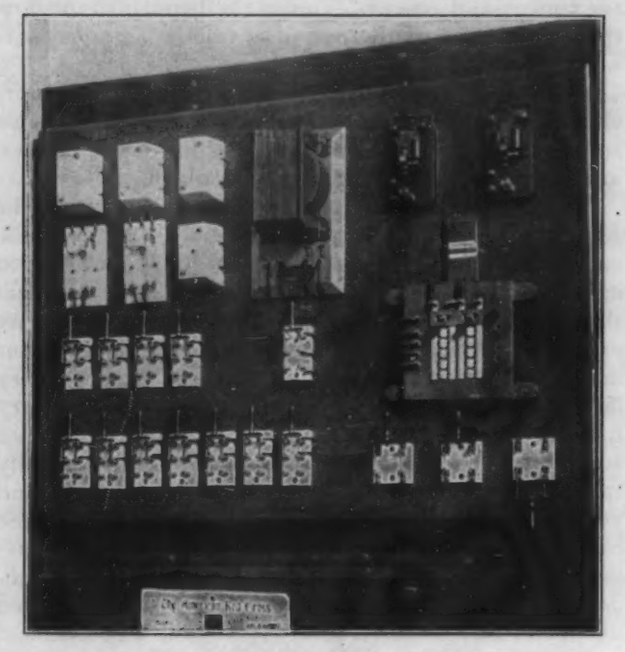
so that the telephone voice currents or the a.c. calling currents are not interfered with. The telegraph batteries are fed from each end of the line, and when not in use are cut off by means of switches. As these batteries are of the closed circuit gravity type it was necessary to provide a means of keeping the batteries working when not in use. This is accomplished by so arranging a switch that it will automatically close the battery circuit through a lamp resistance as soon as the switch opening the batteries from the line is operated. When not in use the telegraph relays are shorted out of the line circuit through a regular plug type telegraph switchboard provided at each station.

Despatcher at Desk

The commercial circuit is of standard magneto construction, using sixteen hundred ohm ringers and five bar a.c. generators. The instruments, however, are specially wired and equipped so that the way-station operators, by the use of a double pole, double throw switch, can use the same telephone on either commercial or despatcher's line.

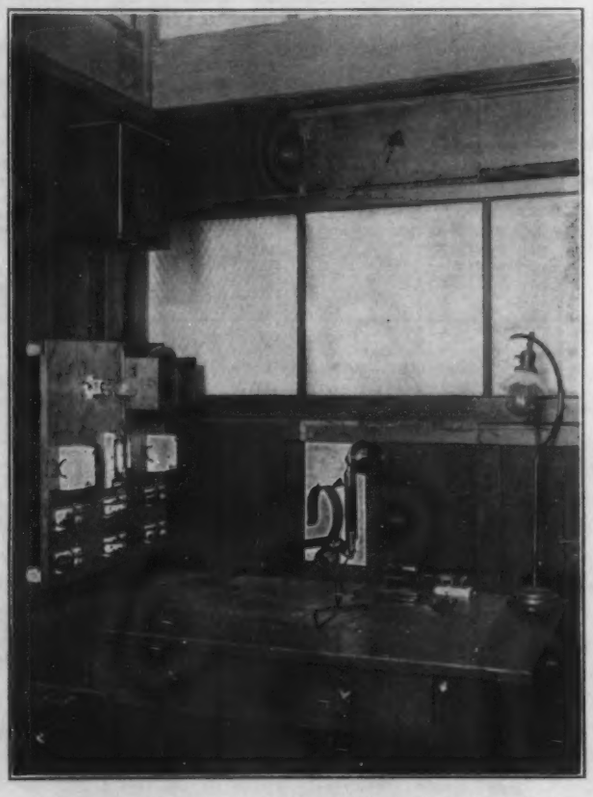
The despatcher's circuit is a metallic line of two hundred and ten pound copper, and no ground connections are necessary for its operation. The Kellogg Switchboard & Supply Company's standard railway telephone apparatus is used in connection with the

Gill main line selector. An automatic calling key cabinet is provided at the despatcher's desk, this cabinet being equipped with a separate key for each selector on the line. Each key has a given number,



Detailed View Despatcher's Switchboard

and a designation strip is also placed over each row of keys to indicate the names of the various stations. The selector bell of the station desired is rung by



Sacramento Way Station showing Switches and Simplex Coils

the sending of the proper combination of d.c. current impulses over the line. This is accomplished by turning the automatic sending key which operates a train of gears similar to the familiar district messenger call box, and this in turn operates a pony relay which feeds the selector battery direct to the line. All the selectors receive these d.c. impulses, but only the selector set to the correct combination of impulses rings its bell. The despatcher is supposed to be on the line at all times ready to receive communications from any station without being signalled. If for any reason he should leave his desk, by removing his telephone set plug from the jack a bell is automatically cut across the line. If a way-station operator fails to find the despatcher when he calls on the line, by a slight turn of the hand generator this bell can be rung.

The telephone instruments at the way-stations are equipped with condensers and so wired that they can be used on either commercial or despatcher's line, without interfering in any way with the various calls which might be going over the lines. Each way-station set, as well as the despatcher's instrument, is provided with a cut-out button. This button is so wired in the telephone circuit that when in the normal position the receiving efficiency in greatly increased, and when operated the outgoing transmission is likewise increased.

Field Telephone Box

Instead of equipping all trains with portable sets, all sidings and way stations where regular offices are not maintained have been provided with siding boxes containing a telephone set equipped to operate on either commercial or despatcher's line. These sets are provided with a double pole double throw switch so that the instrument can be used on either line as desired. The boxes are locked with station railway locks, and a switch key will let anyone authorized to use the instruments have access to same.

The line is divided into six divisions, and by the placing of knife switches at these division points patching stations have been established. By the operation of these station switches, under the direction of the despatcher, that portion of any line in trouble can be patched around by using the line wires of the commercial circuit until same can be put in order by the troubleman.

The entire system was manufactured and installed under the direction of the Kellogg Switchboard & Supply Company, who, with the aid of the engineering force of the Northern Electric Company, have marked another step in the advancement of this latest means of transmission in the handling of trains, which is being so generally adopted by the railroads to replace the telegraph.

NEW METHOD OF WATER MEASUREMENT BY USE OF ELBOWS IN PIPE LINE.

BY GASKELL S. JACOBS AND FRANCIS A. SOOY.

This article deals with the experimental determination of a new method of water measurements in pipes. A formula is deduced whereby the velocity flowing in pipes can be determined by simply boring taps at the inner and outer edges of an elbow in the pipe line itself and by reading the difference in elevation of the water columns of the inner tap and outer tap the velocity of the water may be computed after

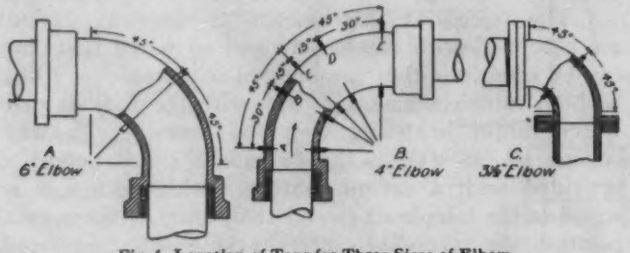


Fig. 1. Location of Taps for Three Sizes of Elbow

measuring the radius of the bend and diameter of the elbow. It is experimentally established that

$$v = 5.60 \sqrt[1.9]{h\frac{r}{d}}$$

Throughout this discussion the following notation is used:

v = velocity in feet per second.
r = mean radius of bend (in feet).
d = internal diameter of elbow (in feet).
h = difference in height of outer and inner water columns (in feet).
Q = discharge (in second feet).
n = an exponent.
A, B, C, numerical constants.

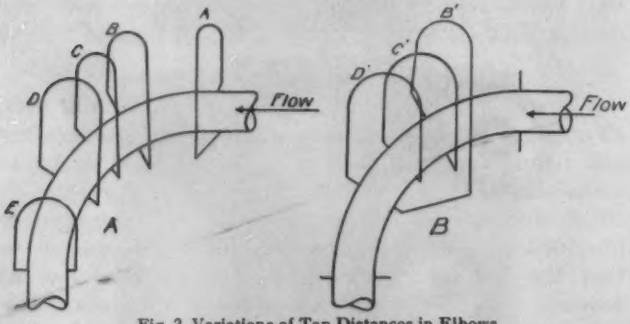


Fig. 2. Variations of Tap Distances in Elbows

Of the present methods of measuring the discharge of a pipe line, the Pitot Tube and the Venturi Meter are the most common. The former has the objection that skill and time and the use of a delicately constructed instrument are required to arrive at a satisfactory measure of flow, while the latter requires an expensive installation and results in a considerable loss of head in the throat piece. With these facts in mind it was suggested to the authors to investigate the possibilities of the use of a ninety degree elbow with properly placed taps as a measuring device on a pipe line. It had been observed and may also be shown from analytical considerations that there is a difference in pressure between the concave and convex side of an elbow. This fact formed the basis of the investigation.

The purpose of this paper is, in presenting the results of a series of tests on elbows, to show that there exists a consistent relation between the flow of water through an elbow and the difference in head between the convex and concave sides of the bend, also to show the possibilities of the use of an elbow as a measuring device.

The general problem was to determine the difference in pressure between the convex and the concave sides of the bend for a series of velocities in the elbows, and for as many elbows as were available.

The elbows used in this work are such as may be found on ordinary water mains, namely, 4 in. and 6 in. cast iron elbows with bell joints, and a 3½ in. flanged cast iron elbow. In their selection, we took care that the interior surface was reasonably smooth, which we examined by means of the insertion of an incandescent lamp. We also took care that there was no very large variation in cross section, and where necessary to secure this condition, any projection on the interior surface was chipped. The elbows were then carefully calipered for interior diameters in both horizontal and vertical planes and at a number of sections along the curves. These measurements were well within one-half of one per cent of the correct values. The mean diameter was taken as the average of all the calipered diameters and the area of cross section was assumed to be that of a circle, having this mean diameter.

The mean radius of the elbow was found by fitting cardboard templets to the concave and convex sides of the elbows, thus determining the inner and outer radius respectively, and the mean of these was taken as the radius of the bend. These radii are known to within five one-hundredths of an inch.

DETAILS OF THE 6 IN. BELL ELBOW.

Description—Standard Cast Iron 90 degrees, 6 in. Bell Elbow.
Taps—1 pair (at middle of bend).
Radius of Bend—

Outer	12.40 inches
Inner	5.45 inches
Mean	5.92 inches
Mean Radius of Bend	0.743 feet

Diameter (internal).

Horizontal (inches)		Vertical (inches)	
6.10	6.15	6.15	6.00
6.15	6.15	6.05	6.00
6.15	6.17	6.00	5.98
6.13	6.14	6.00	6.00
6.15	6.10	5.96	6.05

Average Diameter—6.07 inches.
Average Diameter—0.506 feet.

Area of Section—
Area of circular section.....0.506 ft. in diameter
0.201 sq. ft.

Ratio Radius to Diameter—
$\frac{r}{d}$ 1.47

DETAILS OF THE 4 IN. BELL ELBOW.

Description—Standard cast iron 90 degrees, 4 in. Bell Elbow.
Taps—5 pairs (see sketch, Fig. 2).
Radius of Bend—

Outer	12.60 inches
Inner	7.20 inches
Mean	9.90 inches
Mean Radius of Bend	0.825 feet

Diameter (Internal).

Horizontal (inches)	Vertical (inches)
3.87	3.90
3.80	3.80
3.80	3.80
385	4.00
3.80	3.90

Average Diameter.....3.84 inches
0.320 feet

Area of Section—
Area of circular section of diameter..... 0.320 feet
0.0804 sq. ft.

Ratio Radius to Diameter—
$\frac{r}{d}$ 2.48

DETAILS OF THE 3½ IN. ELBOW.

Description—Standard Cast Iron 90 deg. 3½ in. Flanged Elbow.
Taps—1 pair (at middle of bend)
Radius of Bend—

Outer	7.20 inches
Inner	2.50 inches
Mean	4.85 inches
Mean Radius of Bend	0.404 feet

Diameter (Internal)—

Average Diameter	3.44 inches 0.287 feet

Area of Section—

Area of circular section	0.287 feet diameter 0.0645 square feet

Ratio Radius to Diameter—

$\frac{r}{d}$ 1.41

The pressure taps were placed radially in the concave and convex sides of the elbow at the middle of the curve, and in a horizontal plane which we assumed to coincide with the break of the molds. These openings were carefully drilled (No. 19 drill used), then tapped and fitted with a threaded brass tube to which the gage tubes were attached. On the inside of the elbow a file was used to remove any projection about the opening, so as to leave it perfectly even with the interior wall of the elbow. The location of these taps for each elbow is indicated by sketches as shown in A, B and C, Fig. 1, which also show the elbows in detail. Note that in the four-inch elbow five pairs of taps were drilled to obtain an estimate of how the difference in pressures varied along the curves.

The gage consisted of an inverted glass U-tube of about 3/16 in. interior diameter suspended vertically above and connected by rubber tubing to the brass taps on the elbow. The difference in the water levels of the two sides of the gage gave directly the difference in pressure between the convex and concave sides of the elbow.

All the elbows were tested in a horizontal position. The approach consisted of a flaring intake from a bulkhead and three two-foot lengths of galvanized iron pipe of the same diameter as the inside of the elbow. The joint with the elbow was tightly caulked with a packing of cotton waste and a mixture of resin and paraffine applied hot. The discharge was a single two-foot length of galvanized iron pipe similarly joined to the elbow. In all the tests the approach, and elbow, and discharge were submerged so as to be sure that the elbow was running full of water. The approach and discharge were aligned with their respective tangents, and the arrangement firmly fastended to maintain the alignment throughout the test.

The flow through the elbow was maintained by an impeller pump, direct connected to a single-phase motor, and was measured by standard 2¾ inch circular orifices discharging under a constant head of 6 inches above their centers. The flow was varied by using a greater or a less number of orifices at a time, there being fourteen available. The orifices were all in the same vertical plane 6 inches to center. The entire equipment, elbow, discharge, intake, orifices and pumps were contained in a circulating tank which is shown in Fig. 3.

The head on the orifices was kept constant at 6 inches above their centers by the use of a multiple spillway (see sketch) in the forebay, having about 200 lineal feet of spillway length. The orifices were then carefully calibrated, and when not in use were kept greased to prevent rusting or change. Calibration was performed by measuring the flow for a known interval of time in a tank of known dimensions. A number of the orifices were thus calibrated alone and

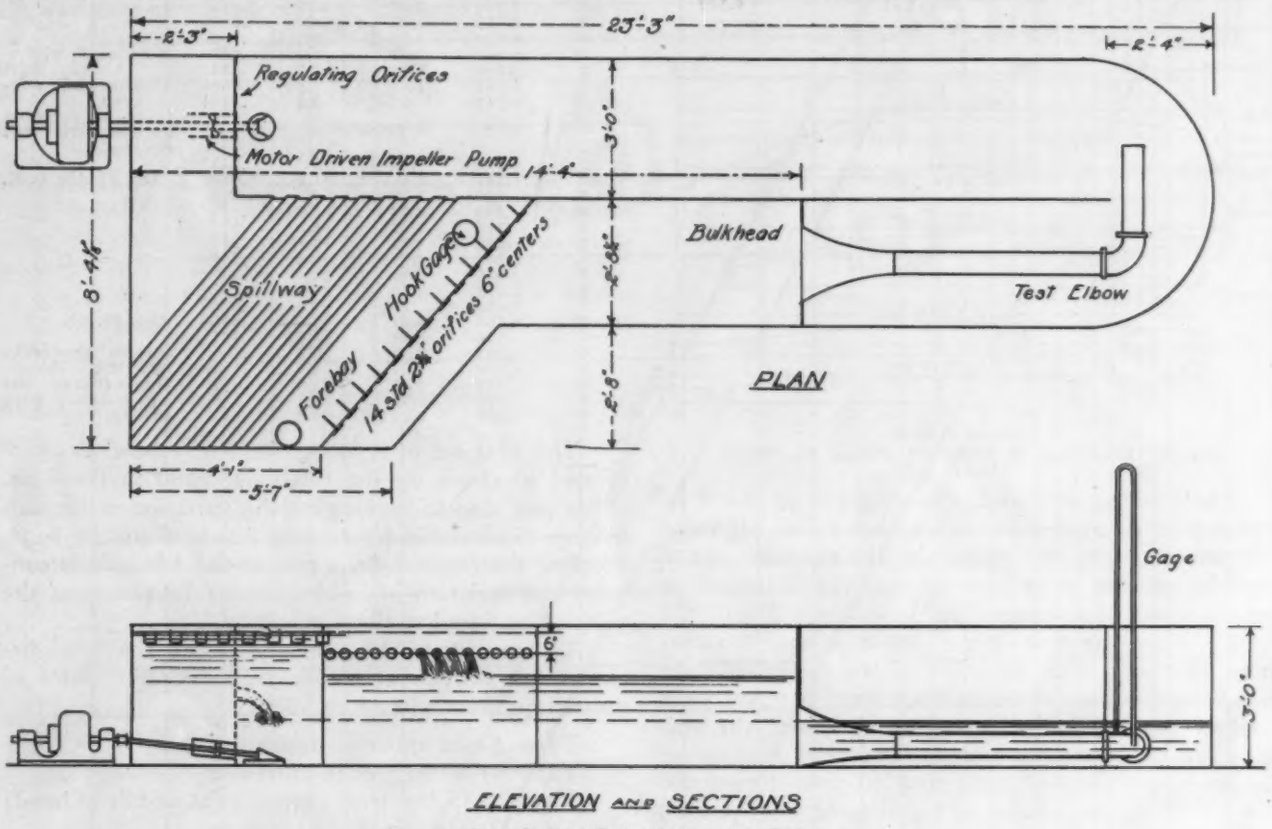


Fig. 3. Detail of Hydraulic Control for Tests

the average discharge for each one was found to be 0.142 second feet very closely, with the constant head of 6 in. above the center of the orifice. In order to determine whether the flow from any one orifice was affected by the flow from an adjacent one, they were re-calibrated under these conditions, but there was no appreciable difference. As a further precaution against interference of flow, permanent wing partitions had been placed between the orifices, extending back into the fore-bay. For the calibration data see Table I.

TABLE I.
CALIBRATION OF ORIFICES.
Dimensions of Calibration Tank 34½ x 36¼.

Orifice Number	Time (Seconds)	Rise (Inches)	Discharge (sec. ft.)
7	70	13.62	0.141
6	65	12.69	0.141
5	60	11.94	0.143
4	60	11.81	0.142
3	60	11.81	0.142
Average discharge for one orifice (cu. ft. per sec.)			0.142

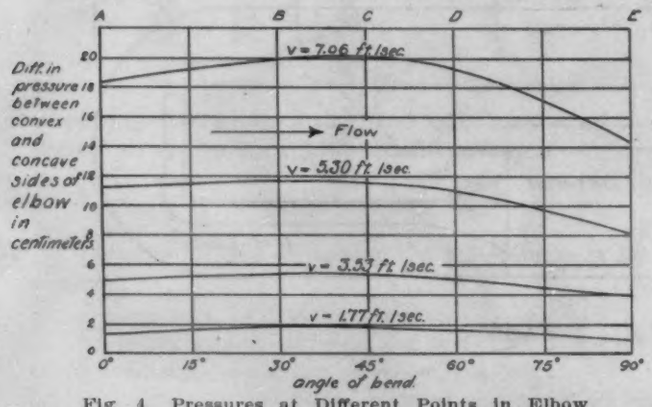


Fig. 4. Pressures at Different Points in Elbow Bend.

The first set of readings were taken on the 6 in. elbow, over a range of velocities from 0.7 to 7.0 linear feet per second in the elbow and the readings of the gage for each of these gave at once the difference in head between the convex and concave sides of the bend. When the flow in the elbow became constant there was very little vibration of the water columns in the gage, so that close readings were possible, only a slight tapping being necessary to insure the stability of the water columns. The zero reading of the gage was checked from time to time during the test. Plotting the results on logarithmic cross section paper as in Fig. 5, shows conclusively that the difference in head varies very closely to the 1.9 power of the velocity. This convinced us that for any particular elbow the variation was at least consistent.

With a tapered intake, a considerable length of approach, and a smooth joint at the elbow, we felt sure that the water reached the curve in a state of normal flow, i. e., the distribution of velocities in the approach was very closely that of a long straight pipe with no obstructions. In order to determine whether an obstruction in the approach a short distance from the elbow affected the reading of the gage due to the resulting disturbance in water in the approach, a brick was placed across the intake so as to direct the water into the approach in a divided stream, which later joined in the pipe. Such conditions as these are common on water mains, there being all sorts of disturbances due to the presence of gates, tees and deposits in the pipe. The observations taken with the obstructions showed that little or no change was produced due to this cause. We thus satisfied ourselves that the condition of the advancing stream caused by disturbance say 10 diameters above the elbow is of little moment as regards the difference of heads between the convex and concave sides of the elbow. See data sheet for 6 inch elbow tests, Table II.

TABLE II.
TESTS ON 6 IN. ELBOW.

Orifices.	Q (sec. ft.)	Vel. in elbow (ft. sec.)	Diff. in Head (cm)	Diff. in Head (ft)	Remarks
1	0.142	.71	0.4	.0131	Head on orifices 0.5
2	0.284	1.41	1.3	.0430	
3	0,426	2.12	3.2	.1025	
4	0.568	2.83	5.5	.180	Jan. 27, '09, normal flow discharge completely covered Gage O. K.
5	0.710	3.54	8.7	.286	
6	0.852	4.25	12.4	.410	
7	0.994	4.96	16.8	.555	
8	1.036	5.66	21.2	.697	
9	1.278	6.36	26.0	.850	
10	1.420	7.07	30.9	1.013	
6	0.852	4.25	12.0	.395	
5	0.710	3.54	9.2	.302	
4	0.568	2.83	6.4	.219	Normal flow.
3	0.426	2.12	3.5	.114	
2	0.284	1.41	1.8	.0590	Discharge covered.
1	0.142	.71	0.5	.0164	(7-10 out rejected as discharge not covered).
1	0.142	.71	0.4	.0131	
2	0.284	1.41	1.4	.0460	Jan. 23, '09, O. K. all.
3	.426	2.12	3.0	.099	
4	.568	2.83	5.3	.174	
5	.710	3.54	8.5	.277	
6	.852	4.25	12.1	.397	
7	.994	4.96	16.4	.540	
8	1.036	5.66	21.4	.700	
9	1.278	6.36	26.1	.851	
1	0.142	.71	0.55	.0180	
2	0.284	1.41	1.5	.0490	Jan. 29, 09.
3	.426	2.12	3.25	.107	
4	.568	2.83	5.7	.186	Intake obstructed with brick.
5	.710	3.54	9.0	.295	
6	.852	4.25	12.5	.411	Discharge obstructed with
7	.994	4.96	16.8	.555	
8	1.036	5.66	20.9	.685	bricks.

The next set of tests on the 4 in. elbow was performed to check up the relations found in the 6 in. elbow and also to investigate the variation in the difference of pressures for various points along the bend. Plotting the results of the run on the 4 in. elbow confirms the variation in head with the 1.9 power of the velocity as found in the 6 in. elbow.

To investigate the pressures along the bend between the convex and concave sides, five pairs of radial taps were placed as follows:

Taps A—at entrance tangent.
Taps B—30 deg. from entrance.
Taps C—45 deg. from entrance (at middle of bend)
Taps D—60 deg. from entrance.
Taps E—at discharge tangent.
See B, Fig. 1.

Simultaneous readings of all five gages were taken for various velocities as tabulated in Table III, and the curves, Fig. 4, were plotted showing as abscissae the center line of the elbow developed and as ordinates the gage readings, for various velocities through the elbow. These curves show that the maximum difference in pressures occurs at the middle of the bend and for sections near the middle it is very nearly the same. Note also that the difference in pressures at the discharge tangent is less than that at entrance tangent, due, perhaps, to the greatly disturbed condition of the water when it reaches the end of the curve.

As mentioned above, the difference in pressures for sections near the middle are very nearly the same, the pressures being measured for taps radially opposite. It was thought that in practice, the pair of taps might not be placed radially opposite, and the ques-

tion arose whether this would give different readings of the gage than for radially opposite taps. The gages were re-arranged as shown in B, Fig. 2. The angular displacement of taps from radial opposition is 15 degrees for taps C and D, and 30 degrees for B, A and E remaining the same. In using the middle pair of taps a displacement of 15 degrees would be quite improbable in practice. The readings of all the gages are tabulated in Set No. 2, Table III, and show in no case a greater variation than 2 per cent from the corresponding gages correctly placed even with the displacement 15 degrees. With small displacements, as might occur in practice the error would certainly be negligible.

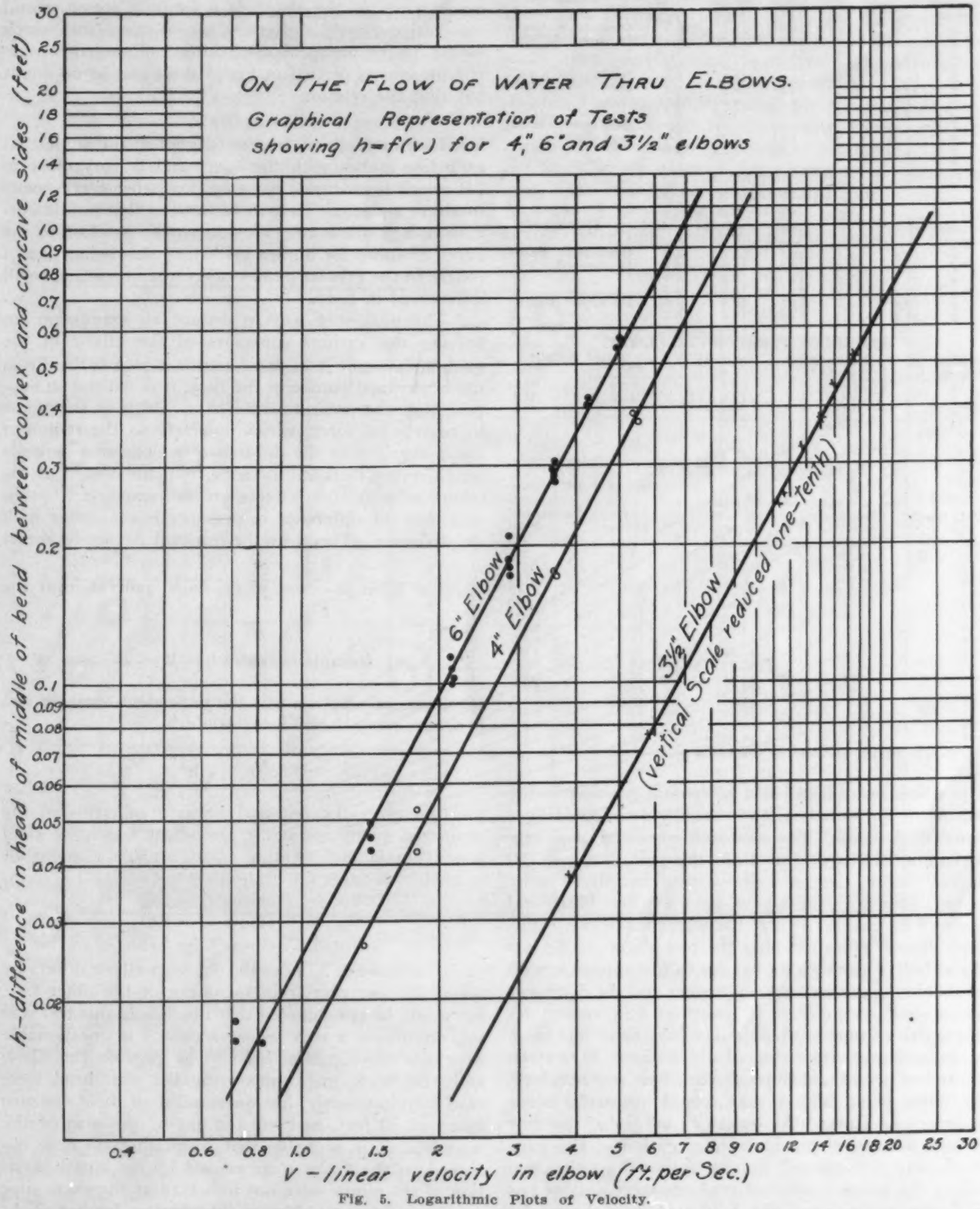

On The Flow of Water Thru Elbows.
Graphical Representation of Tests showing h=f(v) for 4", 6" and 3½" elbows
h-difference in head of middle of bend between convex and concave sides (feet)
V-linear velocity in elbow (ft. per Sec.)
6" Elbow
4" Elbow
3½" Elbow
(vertical Scale reduced one-tenth)

Fig. 5. Logarithmic Plots of Velocity.

The question of the condition of the approach to the elbow and its effect on the difference in pressures was very clearly shown in the test on a 3½ in. flanged elbow. In this test the flow was measured over a 2.5 foot rectangular fully contracted weir in the Hydraulic Laboratory of the University of California.

TABLE III.
TESTS ON 4-IN. ELBOW.
Feb. 9-12, 1909.
See A, Fig. 1, for position of gages as designated below.
SET NO. 1.

Number of Orifices.	Gage Readings (C M) A	B	C	D	E	Remarks.
4	16.1	17.8	18.8	18.3	13.7	Discharge barely covered.
4	16.3	17.9	18.9	18.3	1.40	
4	16.1	17.4	18.4	17.5	1.35	
3	10.6	11.4	12.2	11.5	9.0	
3	10.4	10.8	11.8	10.9	8.5	Discharge covered.
3	10.3	10.7	11.5	10.9	8.2	
2	4.7	4.85	5.27	4.95	3.90	
2	4.4	4.85	5.20	4.90	3.85	
1	1.37	1.25	1.25	1.23	1.04	Bulkhead leaking slightly.
1	1.33	1.22	1.31	1.24	1.03	
1	1.34	1.21	1.29	1.23	1.00	

SET NO. 2.
MAL ARRANGEMENT OF TAPS.
See B, Fig. 2.

Number of Orifices.	Gage Readings (C M) A	B'	C'	D'	E	Remarks.
4	16.8	17.4	18.8	18.1	14.9	Discharge barely covered.
4	16.9	17.5	19.3	17.9	13.4	
4	17.3	17.9	19.4	18.3	14.0	
3	10.3	10.7	11.7	10.9	8.5	
3	10.3	10.5	11.5	10.8	8.4	Bulkhead tight.
3	10.1	10.5	11.4	10.8	8.2	

RESUME OF TESTS ON 4 IN. ELBOW.

Number of Orifices	Discharge (sec. ft.)	Velocity (ft. sec)	Gage Height CM	Ft.
1	0.142	1.77	1.29	.0424
2	0.284	3.53	5.23	.172
3	0.426	5.30	11.8	.388
4	0.568	7.06	18.7	.614

TABLE IV.
TEST ON 3½ IN. ELBOW.
February 19, 1909.

Weir head ft.	Actual Discharge sec. ft.	Vel. in Elbow ft. sec.	Gage Reading Inches	Feet
.079	0.194	3.01	2.68	.223
.097	0.250	3.83	4.5	.375
.125	0.380	5.89	9.3	.775
.126	0.385	5.97	9.5	.791
.163	0.556	8.63	19.0	1.582
.167	0.580	8.99	19.8	1.649
.163	0.580	8.99	19.8	1.649
.193	0.718	11.14	29.4	2.45
.196	0.734	11.39	31.0	2.58
.197	0.734	11.39	31.6	2.63
.210	0.812	12.60	39.4	3.28
.224	0.890	13.81	46.3	3.86
.227	0.910	14.11	47.0	3.92
.227	0.910	14.11	48.0	4.00
.237	0.965	14.96	54.	4.50
.238	0.972	15.07	54.9	4.57
.248	1.036	16.06	62.0	5.17

Note: Width of Weir on crest, 2.5 feet.

The elbow was placed in a horizontal position in the bottom of the weir box, and the flow maintained by a centrifugal pump. The approach consisted of a long horizontal discharge line from the pump—a 4 in. 90 degree elbow, then a 5 ft. vertical length of 4 in. casing, then a 3½ in. elbow, then a 3 foot horizontal run of 4 in. casing, so that the water made two right-angle turns before reaching the test elbow. The test elbow bolted through its flanges to the approach with a rubber ring gasket between flanges and the discharge was a similarly joined 2 ft. length of 4 in. casing. A single pair of taps at the middle of the bend was used. A variation of velocities of from three to sixteen linear feet per second through the elbow was obtained, the latter being higher than would ordinarily occur in practice. Due to the pulsatory nature of the flow at high velocities, considerable vibration of the gage levels was encountered, but by noting the swing and taking the mean, consistent readings were obtained as is shown in the curve, Fig. 5, plotted from the results in Table IV. The approach in this case was such as to produce considerable disturbance in the flow toward the elbow, yet the results were not appreciably affected. This further substantiates the fact that normal flow is regained in a length of ten diameters. In this case as in the 4 in. and 6 in. elbows, the variation in head adheres to the 1.9 power in velocity.

Having completed the experimental work it was next necessary to develop the relations found in the experiments in the shape of a formula which would summarize closely the entire set of tests, and which would be of practical application. From the logarithmic curves plotted in Fig. 5 there can be no doubt but that the relation

$$h = A\,(v)^{1.9}$$

holds for each elbow, for the tangent of the angle that each line makes with the horizontal is very close to 1.9, which logarithmic cross section paper corresponds to above equation. It will be noticed that points corresponding to low velocities do not lie as close to the curve as those for higher velocities, this being due of course to the greater percentage error in reading small differences in head.

The next step was to deduce an expression involving the various constants of the elbow in the general constant A in the equation $h = A\,(v)^{1.9}$. From the centrifugal nature of the flow, it is natural to suppose that the pressure difference, which is analagous to centrifugal force, varies inversely as the radius of the curve. Since the difference in pressures depends on difference in radial distance from the center, of the points at which the effects are measured, it is probable that the difference in pressure heads varies with the diameter. Therefore the constant A may be recast into the form $B - \frac{d}{r}$ and in its most general form the formula becomes

$$h = B - \frac{d}{r}\, v^{1.9}$$

However, in practice, v is the dependent variable and hence its more useful form would be.

$$v = 5.60 \sqrt[1.9]{h \frac{r}{d}}$$

for this gives the required velocity in terms of the measured quantities and a coefficient which we shall now evaluate. Substituting values for v, h, r, and d for a number of cases for each elbow we have

For 6" elbow C = 5.58.
For 4" elbow C = 5.61.
For 3½" elbow C = 5.74.

The value of 5.74 for the 3½ inch elbow differs by about 2½ per cent from the mean of the other two, but it will be remembered that the flow in this test was measured over a weir whose accuracy is questionable to within this figure at least. The gage on the elbow and the hook gage measuring the weir head were read simultaneously, but on account of their distance apart of 10 feet, and on account of the size of the weir box, it is probable that inequalities in flow observed on the elbow gage caused by the speed variation of the pump were not indicated at the same time on the weir gage, thereby introducing further slight errors. Hence the authors feel safe in saying that for small elbows C = 5.60 very closely and the formula holds to within 2 per cent, making due allowance for the accuracy of all methods employed in arriving at this result.

The accuracy of this final result depends on the accuracy of the methods used in determining each of the quantities which enter into it. These we estimate as follows, taking as the error of any set of measurements, the difference between the mean of a set and the measurement of maximum variation

d is measured to within ½ of 1 per cent.
v is measured to within 1 per cent.
h is measured to within 2 per cent.
v is measured to within 4/10 of 1 per cent.

The combination of these according to the above formula gives the accuracy of the combined measurements within 1.8 per cent, or say 2 per cent at the most.

In order to facilitate the use of the above formula the chart, Fig. 6, has been prepared, giving the value of "v" for any pair of values of h and $\frac{d}{r}$.

4. The position of the taps should be radial and exactly opposite at the middle of the bend and in a horizontal plane, but small departures from any or all of these conditions but slightly affects the results. If the elbow is placed in any other than a horizontal position the gage reading must be corrected for the static head corresponding to the vertical distance between the taps.

5. The ordinary 90 degree elbow is a satisfactory measuring device, and for those tested above is as accurate as any method employed at present.

6. The adoption of the elbows as a measuring device has the following advantages:

(a) It is applicable to pipe lines in place, for almost every line has an accessible elbow.

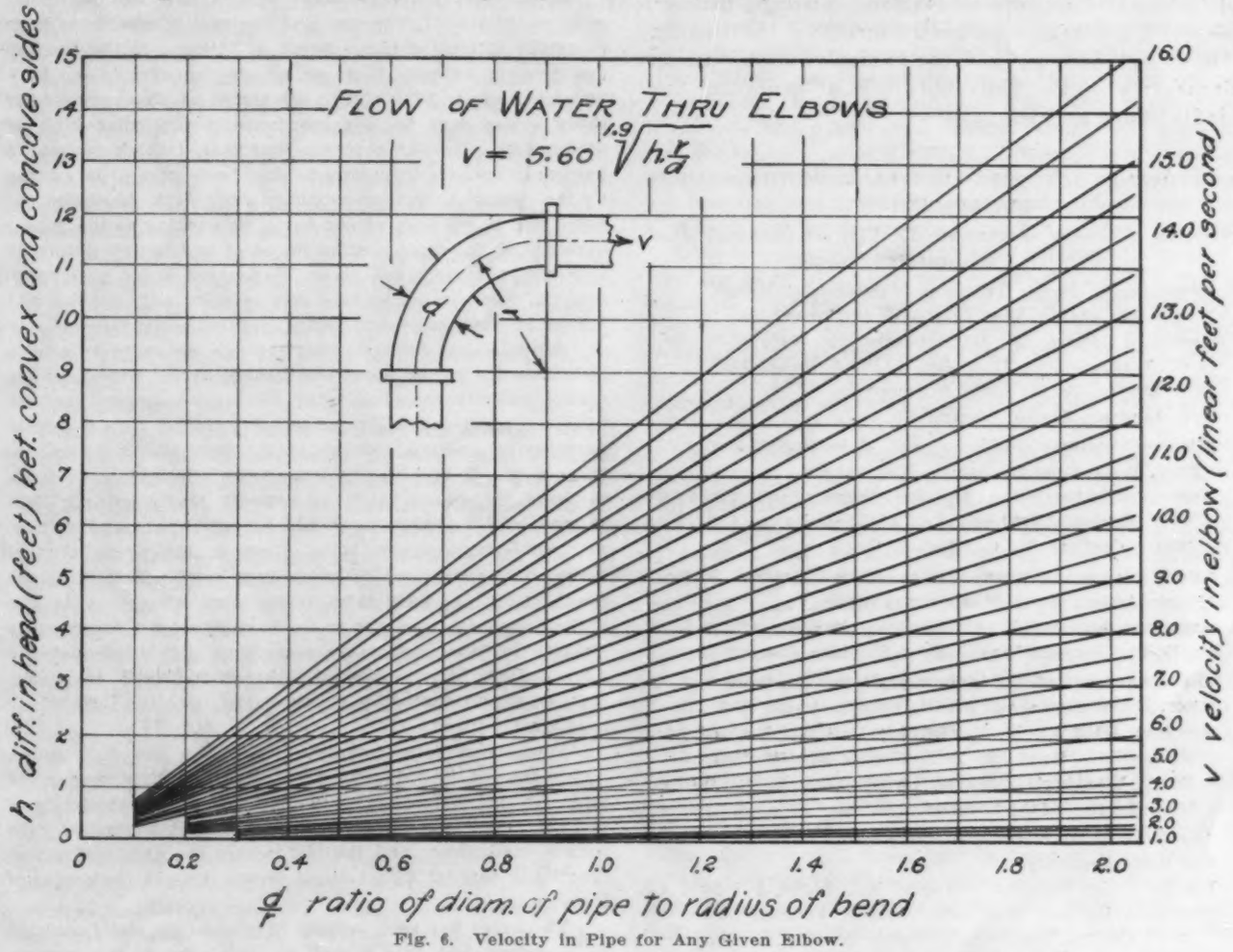

FLOW OF WATER THRU ELBOWS
$v = 5.60 \sqrt[1.9]{h \frac{r}{d}}$
h diff. in head (feet) bet. convex and concave sides
v velocity in elbow (linear feet per second)
$\frac{d}{r}$ ratio of diam. of pipe to radius of bend
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0
v
d
r

Fig. 6. Velocity in Pipe for Any Given Elbow.

Conclusions.

1. There is a consistent relation between the flow of water in an elbow and the difference in pressures between the convex and concave sides at the middle of the bend.

2. The relation as given in formula holds to within 2 per cent for small elbows and probably holds for all sizes with slight modification.

3. Disturbed water in pipe line returns to normal flow after a distance of 10 diameters below the disturbance.

(b) Position of elbow with reference to gates and tees, if the latter are more than ten diameters ahead of elbow, is of no consequence.

(c) Simplicity of apparatus.

(d) Quickness and ease with which the necessary reading is obtainable.

7. With a suitable device for measuring very small differences in head such as a differential gage, the method outlined provides a simple positive determination of small flows such as due to leaks in a pipe line.

8. As a permanent measuring device, the use of a cast-iron elbow with a finished interior surface, say enameled, with permanent pressure taps and re-

cording device is advised. If calibrated, its readings could be depended on to a greater degree of precision than those of some present forms of meters.

The authors regret that lack of time has prevented the further investigation of this problem and its extension to other sizes of elbows. As far as is known, this is the first work in this direction performed to date, and if the results presented here will only tend to stimulate further investigation, the purpose of this paper will have been accomplished.

We desire to express our sincere appreciation and thanks to Mr. Buckner Speed, M. S., of Berkeley, under whose guidance and in whose laboratory the greater part of this work was performed.

We also wish to express our thanks to the People's Water Company of Oakland, through their engineer, Mr. Marks, who kindly furnished the 4 in. and 6 in. C. I elbows, and also the Professors Le Conte and Etcheverry of the University of California for their kindly hints and suggestions.

NORTHWEST ELECTRIC LIGHT AND POWER ASSOCIATION CONVENTION.

Convenes Thursday, September 21, 1911, at Spokane, Wash. Papers to be presented include:

1. "Problems of Power Transmission and Distribution."
   Editor, Mr. Fiskin, Washington Water Power Co.
   Associate Editors, Jno. Harrisburger, Sea. Tac. Power Co.
   H. R. Wakeman, Portland Ry., Light & Power Co.
   D. F. McGee, Pacific Light & Power Co.
   S. C. Lindsay, Seattle Electric Co.
2. "Central Stations Publicity and Commercial Policy."
   Editor, W. J. Grambs, Seattle Electric Co.
   Associate Editors, M. C. Osborne, Wash. Water Power Co. F. F. Barbour, Portland Ry., Light & Power Co. T. L. White (Byllesby & Co., Dalles, Ore.).
3. "New Business Methods for the Small Central Station."
   Editor, Arthur Gunn, Wenatchee, Wash.
   Associate Editors, M. D. Spencer, Eugene, Ore. L. B. Faulkner, Olympia, Wash. Fred Shields, Moscow, Idaho.
4. "Legal Aspects of the Light and Power Business."
   Editor, N. W. Brockett, Seattle-Tacoma Power Co.
   Associate Editors, F. T. Griffith, Portland Ry., Light & Power Co. Hugh A. Tait, Seattle Electric Co., F. T. Post, Washington Water Power Co. R. W. Wilbur, Portland Ry., Light and Power Co.
5. "Methods of Accounting in Connection with the National and State Legislature."
   Editor, C. N. Huggins, Portland Ry., Light & Power Co.
   Associate Editors, Wm. Best, Seattle, Tacoma Power Co. D. C. Coplas, Washington Water Power Co., Auditor or Treasurer Byllesby Co. A. W. Q. Birtwell, Seattle Electric Co.
6. "Central Station Problems."
   (a) "Line Extensions."
   (b) "Question of Meter or Flat Rates in Small Towns."
   Editor, A. C. McMicken, Portland Ry., Light & Power Co.
7. "Meter Accuracy in Relation to Central Stations Increase."
   Editor, R. E. Thatcher, Seattle Electric Co.
   Associate Editors, K. L. Willis, Portland Ry., Light & Power Co. T. G. Finley, Washington Water Power Co. Mr. Snyder, Seattle-Tacoma Power Co.
8. "Electric Heating and Kindred Uses of Electricity."
   Editor, F. F. Barbour, Portland Ry., Light & Power Co.

T. C. Martin, secretary of the National Electric Street Association, will be in attendance.

METHODS OF CALCULATING ILLUMINATION.

Discussion before San Francisco Section, American Institute of Electrical Engineers, on paper presented by L. S. Twomey on June 23, 1911, and printed in these columns on July 1, 1911.

S. J. Lisberger (Chairman): We have listened to an interesting paper this evening on the subject of methods of calculating illumination. There is probably nothing more interesting to the engineer—or nothing that has been more neglected than the subject of illumination. I think some of our mathematical experts have told us that out of the total amount of energy put into the light we get something less than two per cent of its effective value. There are no doubt quite a few members present who would like to ask Mr. Twomey some questions. The paper will now be open to discussion.

C. L. Cory: I don't know that I have any particular question to ask. I, like many of the rest of you, have been especially interested this evening in listening to the theoretical process whereby these extremely practical tables have been evolved; and the author has shown us how very readily these tables may be adapted for any particular kind of illumination. As our chairman has said, I think perhaps a number of us have from time to time been more or less going by the rule of thumb, or groping in the dark, to obtain the result which has been shown here this evening as the proper illumination for some specific purpose; and the conditions in any one room or space to be illuminated differ so largely, that the results given us here may be practically applied, and I think are extremely interesting, and certainly valuable.

Again, it has been running through my mind as I have been listening to the paper and looking at the slides and the curves and the constants, that we are no longer, perhaps, from the purely electrical standpoint, dealing with a certain quantity of electrical energy in the light-giving device; in other words, if you care to consider the incandescent lamp, we have progressed from the ordinary single hair-pin light filament of the carbon lamp without any shade and without any particular concern being given to the shape of that single, hair-pin shaped filament, to a combination of things which, after all, is a lamp much more efficient than the ordinary carbon lamp was in the first place; a filament more complex in form, but at the same time capable of giving a more uniform distribution of light; then finally that combination supplemented by a reflector to place the light where it is most desired.

I was especially impressed with the last few slides, which showed how in the first place the light was more intense at an angle of some 40 degrees from the vertical, and the next slide where the light was almost a vertical tube with a flat bottom; and the last, where the distribution was practically parallel with a circle drawn through the center of illumination.

The paper has been extremely interesting, and I am glad to have been fortunate enough to have followed the development from the purely theoretical standpoint to the extremely practical results that the tables show.

H. Y. Hall: I would like to ask Mr. Twomey to give some method of calculating indirect illumination.

Mr. Twomey: I am very sorry, but I havent anything along that line. I really have dealt very little with indirect illumination and do not know much about it; but aside from that, from all the installations I have seen of indirect illumination, I doubt whether any calculations have been made.

Mr. Hall: Are there any constants that can be used?

Mr. Twomey: Mr. James R. Cravath in the Electrical World of May 11th, 1911, presents a very able article on this subject which seems to be about the only thing available at this time. Mr. Cravath gives a table of efficiency constants for indirect lighting which should be used in a manner

similar to those given in Fig. 13 of the paper under discussion. These constants applied for centrally located fixtures with efficient mirrored reflectors and clean glassware are as follows:

EFFICIENCY CONSTANTS FOR INDIRECT LIGHTING FROM CENTRALLY LOCATED FIXTURES WITH EFFICIENT MIRRORED REFLECTORS AND CLEAN GLASSWARE.

Room Height Feet.	Room Dimensions Feet.	Color Walls.	Color Ceiling.	Per cent efficiency from lamp to working plane.
8.5	12 x 16.5	Lt. Green	Lt. Cream	29.5
9.8	15 x 15.2	Dark Green	Lt. Cream	28.0
9.8	12.7 x 12.7	Lt. Figures	Lt. Cream	37.0
14.5	57.6 x 70	Lt. Cream	Lt. Buff	36.0

It seems to be the opinion of many prominent engineers that in the future we may expect more development along the lines of semi-direct lighting. If we have an Alba reflector or a reflector of similar character inverted, the greater part of the light is thrown up to the ceiling, while a small proportion is transmitted directly through the translucent reflector. It takes away the peculiar cold effect that you may have noticed in direct lighting installations. It seems to be the opinion of quite a number of prominent engineers that this is coming into use.

H. W. Crozier: I would like to ask to what extent the eye strain is due to the varying color of the light. With a carbon light, which is mostly yellow, there is not very much eye strain, but with some tungsten lamps the strain is considerable, and it is noticeable when the change is made from the carbon to the tungsten. Is that due to the increased intensity or more to the color of the light?

Mr. Twomey: You are trying to change from carbon to tungsten?

Mr. Crozier: Yes.

Mr. Twomey: I think that you will find in most cases it is due to the poor installation of the tungsten units rather than to the color of the light. The intrinsic brilliancy of the tungsten filament is many times that of the carbon filament, so that in all cases where lamps are used within the line of vision or where the lamp itself may be seen at all, it should be frosted. For service such as in this room the lamps should always be bowl frosted and equipped with reflectors. As far as effect of the color on eye strain, that seems to be a question for the physiologist to determine.

A. H. Babcock: The question just asked suggests something that is made use of in the design of telescopes where optical work is required; that is, the function of the telescope is to gather as large an amount of light as possible, and draw it to the eye in such shape that it can be recognized—the point of light at a great distance can be recognized. Now it is impossible in the line of lenses to bring all of the spectrum to the same focal plane. Consequently it is the effort of those who design telescopic lenses to bring to the focus as much of the spectrum as the human eye responds to with the greatest activity. For that reason the great Lick telescope is designed to bring the yellow and green to the focus, the red, the lower end of the spectrum goes beyond in one direction, and the violet goes beyond the focal plane the other. One is inside and the other is outside. The effect of this is that when the spectroscope is attached to the telescope, and the tube is rotated in such a manner as to bring various parts of the spectrum to the eye, when you turn from one end of the spectrum to the other you turn slowly, so your eye is accustomed to the light it gets. When the yellow and green come in you almost instinctively close your eye, because there is such a great difference in the intensity. The question just asked suggested to my mind whether that color effect did not have much to do with the tiring effect on the eye. I realize quite fully that the direct light of a very brilliant source does tire the eye; but the fact that the human eye has for many centuries been adapting itself to a preponderance of yellow rays which we get out of the sunlight would indicate to me that the eye is best adapted to recognize the yellow and green rays. That is taken advantage of, as I say, in the construction of great telescopes, where the quantity of light and its effect on the eye are of the utmost importance.

The paper of the evening has been very interesting to all of us who have had to do with lighting and with illumination. I regret very much that this meeting is not attended by every architect within reach, because my experience has made me feel that architects above all others are the most ignorant on the subject of scientific illumination. I have had several times to clear up some lighting messes made by some rather important architects; and the utter disregard that is shown to common-sense methods in illumination is something astonishing to one who has not run into it. In one of our large draughting rooms in the general offices of the Southern Pacific Company the draughtsmen complained they were not getting light enough. There were 16-candlepower carbon lamps high up in the ceiling, so the architect in charge of the building simply doubled up h's candlepower. Then the wiring was not adequate for the double load, and the voltage dropped off. It was only by the force of an order from the proper authority that the man was made to consider the use of a proper lamp, with a proper reflector back of it.

Now that man is not an ignorant man. One piece of work that he did you gentlemen saw at the last meeting; but when it came to lighting he was the most pig-headed man that I have had to do with. It is not confined to him. It is characteristic of the breed. They don't know; and they don't know that they don't know. It is a subject which is extremely irritating to a man who deals directly with precise methods; and I think that some of you lighting experts would do well to convert a few architects if possible to a more rational view of things.

Mr. Twomey: In some cases, Mr. Babcock, our efforts to convert the architects have met with about the same results as you mention.

Mr. Cory: There is nothing like getting a large number of opinions that we know are coming from very different sources. I would like to ask Mr. Vincent if he can give us any experience that he had about lighting a very large room from the ceiling I think about 100 feet from the floor?

W. G. Vincent: I don't know that I have anything special to say about that room, because it has not been used yet. I am waiting to see what the result is when it is used. But I have found this great difficulty, that the personal equation enters so much into the question of lighting. For instance, I like a general illumination. I don't like a light right in front of me reflecting on the table; but it seemed to be the idea of the architect in this case that each reading table should have a lamp right in front of it. I think the tiring effect that Mr. Babcock speaks of is due to the excessive light on the paper reflecting on the eye. Light on the paper sufficient for reading purposes would not have that tiring effect. I was trying to hold down to general illumination from above which would be sufficient, and not in excess to tire the eye.

I think the principal work of the illuminating engineer is to get the location of outlets properly spaced; because the conditions of usage of rooms vary so much that it is hard to say just the quantity of light to suit all conditions; and I think the principal thing in a building is to get the spacing properly laid out; after that is done it can be suited to the conditions of the room. Isn't that what you think, Mr. Twomey?

Mr. Twomey: Yes, I believe that is so.

Mr. Vincent: The conditions of the painting and tinting of the rooms vary from time to time, and it seems impossible to figure out what the particular color is going to be; but the architect always has ideas about the artistic effect of the

spacing of the outlets, which do not agree with the engineering.

A Member: One of the speakers has mentioned the difficulty of having the architects take up the question from the engineer's point of view. I believe it is true that in many respects it is the fault of the electrical engineer that difficulties arise, and I believe that if there were some effort made to have the speakers of the different societies of the city speak on these subjects, it would remedy some of the conditions mentioned. I would suggest, therefore, that it be taken up with the executive committee, with a view to having some of our speakers address the American Institute of Architects, and some of them address us. No doubt we can learn something.

Mr. Babcock: I would like to ask the author what he considers to be a fair method for a contract between a municipality and the lighting company for street illumination: whether or not it is possible to make a contract on the basis of a certain minimum illumination—so many foot-candles at any point along the street; and whether it would be possible to draw a contract in that way which would be fair to the municipality and to the lighting company, to specify the minimum illumination by foot-candles at any point of the street?

Mr. Twomey: The way that is generally done is to get up plans and specifications for the lighting, and not only specify candlepower, but specify the location and equipment and reflectors and so forth. When that is made out by competent engineers they secure the result desired that you speak of. This is simply another way of getting at it, although I have heard of them specifying a certain equipment and efficiency of units.

Mr. Lisberger: I think that could be done if the city had enough to pay for the lighting, or the lighting company could make a low enough rate to meet the city's financial condition. I think you would run into a number of difficulties in attempting this except on well-lighted streets. For example, take Market street, or Broadway in Oakland, where you can absolutely space lights at a given interval in case the city could afford to do that; but if you take scattered territories I don't think you could do it, particularly when you take into account tree conditions, where it would be absolutely impossible to live up to them, even with any type of lighting you might put in.

I don't know whether I caught your point or not.

Mr. Babcock: No, I don't think the Chairman does quite cover the point. Of course if the streets are entirely covered with trees so they arch over the roadway it is a very serious difficulty, especially if the trees should be low. But suppose you had a case, for example, as we have sometimes now, where a municipality, in granting a railway franchise, calls for the street to be illuminated. The railroad company, in part consideration of its franchise, agrees to light its streets. There is a practical question. As some of you know, there is a tendency here in this district nowadays to insert such a provision. The question immediately arises, What kind of light? My contention is, it is none of the municipality's business what kind of light is put there. What they are after is a certain illumination of the street. That is the practical thing that we are after. The question is, as far as the railroad is concerned, how far ahead of a moving train can a man or wagon be noticed by the motorman; and that, to me, is the practical point involved in this case.

Now over in Oakland the City Council has demanded this point in some of our franchises. Questions may arise, What kind of light? I deny, as I said before, it is any of the business of the municipality. It was our business to ask for a definite specification as to the quantity of light at any given point. In one case there was a city electrician who was amenable to reason. There was a provision of that kind put into the franchise, that a minimum illumination of .01 foot-candle should be furnished by the railroad, the choice of the apparatus to lie entirely in the railroad company's hand, but the design of the fixtures to be approved by the Board of Public Works. Under that franchise there has been no lighting done so far; but I have no doubt it can be worked out. There is also in that franchise a method for determining the illumination at any point along the street, the provision being to calculate from the manufacturer's certified curve of the lamp used what the illumination will be.

The point I had in mind was to find out whether any other contract of that kind was known, and if so, how it worked out, and whether the author thought it was practical to work such a thing to a conclusion.

Mr. Twomey: In the case of low units and improper reflectors with excessive glare, although the foot-candle intensity may be high enough at any point the glare might be so great that there would be a great deal of difficulty in distinguishing objects far ahead of the train, especially objects on the other side of light source. When you have low units of great brilliancy in a poor installation, the foot-candle intensity might be decreased and by installing a properly designed system better results would be secured.

Mr. Babcock: Wouldn't it be the tendency of the engineer of the railroad company to give as low an intensity as he could? It seems to me it would be my business in that case to get as much illumination from the source of light as possible; and in this particular case we had to consider incandescent lamps for that reason, which would produce the .01 candles.

Mr. Twomey: That is apparently ample illumination as far as the elimination of danger from moving trains is concerned.

Mr. Babcock: How would that compare with the ordinary street illumination?

Mr. Twomey: A minimum of .01 foot-candles compares very favorably except with the lighting in business districts; there it runs as high as 0.10 foot-candles in some cases. The minimum illumination specified frequently for residence districts is .004 foot-candles.

Question: Isn't it a fact that most of the methods used in the streets are very inefficient.

Mr. Twomey: I should say they are.

Mr. Lisberger: I presume there is no more inefficient type of lighting than the so-called electrolier lighting. An endeavor to produce a proper illumination has been made by one company—I don't know the name of the company that manufactures the electrolier—but it has got a little different shape of globe than that before used. I don't know whether you have seen it. There were some samples of it on Kearny street. The electrolier arm ordinarily coming out like this (drawing diagram) contains a globe something of that shape. In the San Francisco electroliers there are four of these downward, and one on top of the post. The new globe is shaped very much like this (drawing illustration); the lamp is visible if you get almost underneath the electrolier. This in here is fluted, very much like a holophane—in fact it may be a holophane production—

Mr. Twomey: I do not recognize it.

Mr. Lisberger: They were first used in Cincinnati. The lamp is right in here (indicating), and if you get under the electrolier you can see it. It is not nearly as pretty a globe to the eye in daylight as the ordinary round shape of globe; but as far as area of illumination in its vicinity is concerned, and improving the lighting of the street, it is 50 per cent better than your old electrolier.

Mr. Twomey: The Holophane Company has a new lighting unit which consists of reflector shaped something like this, a prismatic reflector which has a similar distribution to that of the extensive type explained some time ago. The

prismatic reflector is surrounded by an opal envelope and has an ornamental holder at the top. The unit has a distribution curve something like this, the maximum occurring at such an angle as to avoid excessive glare and to give approximately uniform illumination with a ratio of height to spacing of approximately 1 to 4. With an opalescent ball with this same lamp you would have a distribution curve approximately like this; you will see that the two are radically different.

Mr. Lisberger: And it is a great improvement on the old type of electrolier.

Mr. Twomey: They may be located in a bad position so as to cause reflection from the paper back into the eye. The correct direction for light for reading is from over the left shoulder so that the light is reflected from the paper to the front instead of back into the eye.

Mr. Cory: If I say just a word here again, I think the point that has been discussed about street lighting and the minimum illumination, can perhaps be used directly in the illumination of a certain room. The room that Mr. Vincent had in mind and I had in mind is the reading room of the new Doe Library, the gift of Mr. Charles F. Doe to the University of California, which, if I am right in my recollection, is some 200 feet in length by 100 feet wide—

A Member: Fifty feet.

Mr. Cory: What I wanted to bring up is this: Might it not—if we cannot do this matter of specifying illumination for municipal lighting—be a good idea in getting the illumination for such a room, to specify not only minimum illumination but maximum illumination as well. I remember quite well the work that was done in connection with that room; and I do not hesitate to say that the work was done along the line that has been brought out here this evening. The architect was not in sympathy with the work to be done at all. The situation was practically this: if all the lights in the room were put out except this one, and it were determined that the proper foot-candles on a table was correct for the average person reading, how shall we proceed in the most economical manner for the consumption of electric current to give a general illumination over the tables that are to be used, from the ceiling without the individual lamps? And I think, as has been brought out here this evening, if that particular problem in such a room as that is attacked in the right way we might get a general illumination, which would be not too much greater or too much less than you would get by your individual light. It is only carrying the point one step further, and not to stop with the minimum, but making it impossible to go beyond the maximum, partcularly when the strain on the eye is to be considered.

A. J. Bowie: I might say a word in regard to the subject before us. In the Mechanics' Library the tables are arranged with very handsome two-light fixtures covered with green shades, and I have found a great deal of eye strain. I cannot say why it is, but presumably the high intensity and reflections; which is another point that should be considered. I would like to ask what results you get from indirect illumination. One gentleman I know has had very good results in a drawing room. He had four different candlepower lamps in a drawing room about a quarter as large as this room we are sitting in; and another example I have seen of it in the Wells Fargo Nevada Bank, where the illumination seemed to be bad indeed. Do I understand this matter of indirect lighting is in an experimental stage?

Mr. Twomey: It can not be figured as exactly as direct lighting, and the size and shape of the room are more important factors than in direct lighting. The method of calculation is not at present in as highly developed state as for direct lighting.

Mr. Bowie: What do you suppose was the matter down in the Mechanics' Library? I believe 25-candlepower tungsten lamps with green shades are used, and the lamps 16 to 18 inches above the table.

Mr. Twomey: They may be located in a bad position so you get a reflection from the paper back into the eye. The correct position for a light in reading is from the left shoulder, and the reflection goes away from the front of the light.

Mr. Cory: One question: Don't you think yourself, from your own experience, that you would not undergo that same eye strain if, instead of having these concentrated units close to you, allowing very great variation in the intensity of light, where you get the proper illumination, and then again practically none, there would be less eye strain if there were uniform illumination above, as in the case of daylight?

Mr. Twomey: Yes.

Mr. Cory: I think, when you come to the tungsten lamps, which is an economical means of consuming current, you have to go one step farther, and not locate them so close. Even in your reading room and library, get general illumination.

Mr. Babcock: I don't think the root of the matter has been touched yet. The human eye adapts itself to the maximum light, that is to say, the pupilary contraction comes in and the aperture closes automatically until the maximum light admitted is acceptable to the eye. Now when we are reading or drafting—anything of that kind—we are concerned with contrasts, and nothing else. The eye is picking out from a background a certain thing that the brain wishes to recognize. That may be type, or lines, or what not, but that contrast is what we are after. Now if on the page we are looking at there is a very brilliant light, the eye closes, the pupil closes to that illumination, and it is practically impossible to see the thing we are looking at. That can be tested by any one of us in a very simple manner. If, for instance, a source of light of this kind is available, simply turn your back on it, and just over the edge of your book put a bright light out in front of you, and how much are you going to see of that page? Nothing. It is the direct illumination of the source in front of you that your eye is accustoming itself to. Turn that light out, and at once the page appears to be brighter. It is not that the page is brighter, but the contrast between the maximum illumination coming into the eye, and the thing you are recognizing, is lost.

I have a photographic dark room, and I go on the theory that a maximum illumination in there is what I am after. It must be of a certain chemical quality. Consequently it is painted canary yellow to avoid reflections of stray light that might come in. If it wasn't that fear of a leak I would have the inside of my dark room as white as possible, but I want only the light yellow to be reflected in case of a leak. I have all the red light I need. There must be no green or yellow; it must be as near a chromatic red as can be obtained. The consequence is I can read a newspaper in the dark room. Why? Because my eye is concerned solely with the contrast between the black type and a certain background that looks red. Consequently I can see the black, and read any paper perfectly.

To me that is the theory of correct illumination—to have as little light as possible to get the contrast. This idea of putting a light of high intensity down low on a desk and then attempt to work by it is rot. You tire your eye; and yet our architects will go on and on and do that very thing and keep on doing it. What is the purpose of the reading room? Is it to attract people to come in from the outside? No. It is a mere fool business method of an architect, who will erect an artistic establishment at the expense of the comfort and the use to which it is put.

Mr. Lisberger: Mr. Twomey, in some of the slides you showed, there was in the case of the holophane reflector a certain amount of light given behind the vertical line, up in here (indicating). Was that intentional or not? You had

some of your curves coming down like that (indicating).

Mr. Twomey: That is really intentional, because it is desired to have some light there. That ceiling reflection makes some increase over the illumination calculated by the "point by point" method. Where you have light walls and light ceilings it increases as high as 75 per cent in some cases, I think.

Mr. Babcock: I would like to add something to the remarks I have just made, illustrating the point that it is a question of contrast.

Those of you using a film on a kodak to take photographs know that on the little black piece of paper you pull out there are some spaces left for making notes. It is my habit in taking photographs to note on that little black slip of paper the length of exposure, the stock used, and whatever notes may be of value in the development of that particular film. When I take that into the dark room I use a black piece of paper with a lead pencil mark on it. One ordinarily would think this would be utterly illegible; but in the red light you have precisely the effect I speak of. The black paper is glazed, and reflects the light. The trace of the pencil on the paper does not reflect the light; and consequently you have the appearance of a dark line on a background that is easiyl seen. It is a luminous background for the time being reflecting the red light that you get, and the black pencil lines don't show. Consequently the black line on a black ground can be read as easily as on a piece of white paper here.

Mr. Lisberger: I think we owe Mr. Twomey a vote of thanks.

Mr. Babcock: I will be very glad to make a motion that he has our sincere thanks for this evening.

Mr. Lisberger: We have all appreciated Mr. Twomey's efforts on our behalf, and I am sure we have learned a great deal from his paper tonight. The meeting stands adjourned.

F. W. Loomis (contributed): On looking over Mr. Twomey's paper on "Methods of Calculating Illumination" I noted how thoroughly the subject had been covered.

Some of the tables used, however, are not as complete as they might be, and it may be of interest to those in the illumination field to see these tables augmented.

Under the heading, "Point by Point Method," Mr. Twomey truly states no account is taken of wall and ceiling reflection. A test was made some time ago by the engineers of the Holophane Company that has been developed into a table of very interesting figures.

The room where the test was made was 25 feet long, 12 feet wide and 10 feet high. Light and dark conditions of ceiling, walls and floor were tested. For the dark covering a very dark green burlap was used, while a light straw-colored semi-matte wrapping paper was chosen for the light conditions. The tests were made with one light source in the center of the room, close to ceiling, and again with three ceiling outlets. The first series of tests the lamps were clear and bare, while the second series, the lamps were bowl frosted and under extensive type of Holophane reflectors. With each of the above equipments (i. e., one or three-light sources and without or with reflectors) eight tests were made thus, giving all possible combinations of light and dark walls, ceiling and floor. The engineers were thus able to classify each increase. Not only did the expected increase due to light surroundings occur, but there also showed an additional increase due to what may be termed interaction of ceiling and walls. The summary in brief is as follows:

N1=Increase due to light ceiling alone.
N2=Increase due to light walls alone.
N3=Increase due to light floor alone.
N4=Additional increase due to interaction of light ceiling and light walls.
N5=Additional increase due to interaction of light ceiling and light floor.
N6=Additional increase due to interaction of light walls and light floor.
N7=Additional increase due to interaction of light ceiling, light walls and light floor.

NOTE: For complete data on this test see "Some Experiments on Reflection from Walls, Ceiling and Floors," by Lansingh and Rolph. Illuminating Engineering Society Transactions, Vol. 3, 1908, Page 584.

By analysis the following table of numerical values was obtained:

	LIGHT SOURCE.			
	1 lamp bare. Per cent increase.	1 lamp with refl. Per cent increase.	3 lamps bare. Per cent increase.	3 lamps with refl. Per cent increase.
N1..	79	33	96	29
N2..	63	19	77	26
N3..	11	5	4	0
N4..	53	23	54	37
N5..	6	0	6	4
N6..	5	12	11	11
N7..	42	58	60	45
Total	258	150	308	151

Of these only four are of material value:

N1=Increase due to ceiling alone.
N2=Increase due to walls alone.
N4=Increase due to interaction of ceiling and walls.
N7=Increase due to interaction of ceiling and floor.

The increase due to light surfaces is, of course, greatest when bare lamps are used as more light goes to the ceiling and walls; but the losses are proportionately greater if the reflection co-efficient of such surfaces are low. Thus is apparent the value of the redirecting power of a good reflector to control the light rays and send them in a useful direction. With the bare lamps, near the ceiling, the result would be an extremely brilliant spot on the ceiling around the source, which compared with less intensity over balance of ceiling, wall and floor surface, again shows the need of the proper distributing reflector to give uniform illumination.

The following table applies in general for increase in actual over calculated illumination, in small or moderate sized rooms, when Holophane reflectors are used:

Condition of ceiling.	Condition of walls.	Increase over calculated illumination.
Very dark	Very dark	0%
Medium	Very dark	15%
Medium	Medium	40%
Very light	Very dark	30%
Very light	Medium	55%
Very light	Very light	80%

These figures should not be used in connection with the tables—Lumens per watt constants, Fig. 12, nor illumination constants, Fig. 13, of Mr. Twomey's paper, as in these tables consideration has been given to effect of wall and ceiling reflection.

Below is a more complete table covering the lumens per watt constant than that given in Fig. 12.

Note.—These constants are correct for the lamps only

WATTS REQUIRED TO ILLUMINATE A ROOM.

The following constants apply where one has a medium or large room; lamps hanging pendant 10 to 17 feet above floor.

Lamps.	Equipment.	Ceiling	Walls	Constant
Tungsten 1.25 w.p.c.	Clear Holophane	Light	Light	5.0
" " "	" "	Light	Dark	4.0
" " "	" "	Dark	Dark	3.4
" " "	Enamelled or satin finish	Light	Light	4.3
" " "	" " " "	Light	Dark	3.4
" " "	" " " "	Dark	Dark	2.8
Gem 2.5 "	Clear Holophane	Light	Light	2.2
" " "	" "	Light	Dark	1.8
" " "	" "	Dark	Dark	1.5
Carbon 3.1 "	" "	Light	Light	1.8
" " "	" "	Light	Dark	1.5
" " "	Lamps bare	Light	Light	.6 to 1.3
" " "	" "	Light	Medium	.5 to .8
" " "	Opal Dome or Cone	Light	Dark	1.4
" " "	" " " "	Light	Light	1.7

when operated at their rated watts per horizontal candle-power. For lamps operating at other efficiencies, the change in this constant is universally proportional to the ratio of the watts per candle.

The following is a more complete table of foot-candle intensities recommended than will be found in Mr. Twomey's Fig. 11. This table covers the various classes of service most thoroughly:

Arcade (in addition to light received from show windows)	1.00
Armory or Drill Hall	2.0
Art Gallery (walls)	5.0
Auditorium	2.0
Automobile Showroom	5.0
Automobile (interior)	1.0
Ballroom	2.0
Bank	3.0
Barroom	3.0
Barber shop	2.5
Bath (public)	
Dressing Rooms	1.0
Swimming Pool	2.0
Billboard	8.0
Billiard Room (general)	.8
Billiard Table	5.0
Bowling Alley—	
Alley	1.5
Pins	4.0
Cafe	2.5
Cardroom	2.0
Carpenter Shop	2.5
Cars—	
Baggage	1.0
Day Coach	2.0
Dining	1.8
Mail	7.0
Pullman	2.0
Street	2.0
Courts—	
Handball	7.0
Squash	7.0
Tennis	7.0
Courtroom	2.0
Church	2.0
Club—	
For various rooms, see Bath, Hotel, Residence, etc.	
Dance Hall	2.0
Depot (waiting room)	1.5
Desk	4.0
Draughting Room	8.0
Engraving	10.0
Factory—	
General illumination only, where additional special illumination of each machine or bench is provided.	1.5
Local Bench Illumination	4.0
Complete (no local) illumination	4.0
Fire Stations—	
When alarm is turned in	3.0
At other times	1.0
Foundry	3.0
Garage	2.0
Gymnasium	2.5
Hall—	
See Auditorium, Corridor of Hotel or Office Bldg.	
Hospital—	
Corridors	.5
Wards (with local illumination supplied)	.5
Wards (with local ilumination supplied)	.5
Operating Table	12.0
Hotels—	
Lobby	2.0
Dining Room	2.0
Writing Room	2.0
Corridor	.6
Bed Room	1.5
Laboratory	3.0
Laundry	2.0
Library	
Stock room	1.5
Reading room (with no local illumination supplied)	3.5
Reading room (with local illumination supplied)	.7
Lodge Room	2.5
Lunch Room	2.0
Machine Shop (general)	1.0
Market	3.0
Moving Picture Theatre	1.5
Museum	3.0
Office	4.0
Opera House (see Theater).	
Pattern Shops	3.0
Pool Room (general)	.8
Pool Table	5.0
Power House	2.5
Postal Service	7.0
Press Room	4.0
Public Square	.8
Reading (ordinary print)	2.0
Reading (fine print)	2.5
Residence—	
Porch	.2
Porch (reading light)	1.0
Hall (entrance)	.7
Reception Room	1.5
Parlor	1.5
Sitting Room	1.5
Library	2.0
Music Room	2.0
Dining Room	1.5
Pantry	2.0
Kitchen	2.0
Laundry	1.5
Hall (upstairs)	.5
Bedroom	1.5
Bathroom	2.0
Furnace Room	.7
Storeroom	.7
Restaurant	2.0
Rink (skating)	2.0
Rug Rack	15.0
Saloon	3.0
School—	
Class Room	2.5
Study Room	2.5
Assembly Room	2.0
Office	2.5
Cloak Room	.8
Corridor	.8
Manual Training	3.0
Laboratory	3.0
Drawing	5.0
Sewing (light goods)	4.0
Sewing (dark goods)	8.0
Shipping Room	1.5
Show Window—	
Light Goods	8.0
Medium Goods	16.0
Dark Goods	20.0
Sign	8.0
Stable	1.0
Station (railroad)	2.0
Stereotyping	4.0
Stock Room	1.0
Store—	
Art	4.0
Baker	3.0
Book	3.5
Butcher	3.5
China	2.5
Cigar	3.0
Clothing	5.0
Cloak and Suit	5.0
Confectionery	3.0
Decorator	3.0
Department (see each department).	
Drug	3.0
Dry Goods	4.0
Florist	3.0
Furniture	5.0
Furrier	5.0
Grocery	3.0
Haberdasher	3.5
Hardware	4.5
Hat	4.0
Jewelry	3.5
Lace	3.0
Leather	3.5
Meat	3.5
Men's Furnishings	3.5
Millinery	4.0
Music	3.0
Notions	3.0
Piano	4.0
Post Cards	3.0
Shoe	3.5
Stationery	3.5
Tailor	4.0
Tobacco	3.0
Street—	
Business (not including light from show windows and signs)	.5
Residence	.1
Prominent (in residence districts)	.2
Country Roads	.05
Studio	4.0
Telephone exchange (general)	3.0
Theatre—	
Lobby	3.0
Auditorium	2.0
Train Sheds	1.0
Typesetting	8.0
Warehouse	1.5
Wharf	1.0
Y. M. C. A. (see Clubs)	

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Application High Frequency Tests

Nicola Tesla in a recent lecture promises the world that at an early date he will be able to transmit through the bowels of the earth selective wireless messages which can with ease be read in the heart of the Sahara Desert or in the great commercial centers by a receiver carefully tuned to that of the sender, wiping out all hitherto shortcomings of wireless telephony or telegraphy so far as impediments due to distance, location or interference are concerned.

In these days of progress, scientists stand aghast, wondering what great advance will next be made. I is not necessary to speculate on future dreams and prophesies, however, for realities of the present afford us abundant food for thought. The intricate and delicate phenomena attendant upon high frequency variations seem to afford the greatest field for immediate useful application. Already it is bearing fruit. The study of the selective use of wave frequency of such lengths as are visible to the eye have resulted in enormous increases in lighting efficiencies. On the other hand, application of different wave frequencies in telephony have resulted not only in selective signalling, but also in the extension of the modern telephone use over distances that were thought absolutely impracticable but a few years back. These improvements in the telephone have resulted in its present almost indispensable use in the despatching of railroad traffic, both electric and steam.

As to Rate Reductions

Complete reports for 1907, the latest year for which full data are available, show that an average of 4.47 per cent interest was paid on the $600,677,685 outstanding bonds of electric light and power companies in the United States. On the $75,313,725 preferred stock an average of 3.21 per cent was paid in dividends and on the $666,003,772 common stock then outstanding an average of 2.53 per cent was paid. This is an average of 3.44 per cent paid in 1907 on a total capitalization of $1,341,995,182 for the electric light and power industry in this country.

The investors who received such small immediate returns on their money should be encouraged by the community's being thus provided with the greatest convenience of modern times. In lightening labor, dispelling darkness and diminishing distance, electricity has become well-nigh indispensable. But without capital it is well-nigh impossible. Yet capital, naturally timid, is scared away by arbitrary rate reductions and threatening municipal competition in a field which statistics show is little more than self-supporting. The investor is discouraged and forced to seek other channels, for money is fluid, though capital is not necessarily water. It is easily diverted by small obstacles.

These obstacles can be removed. Public service commissions are raising unreasonably low rates and stabilizing the business. Each year finds new uses and new users. The corporations are endeavoring to please those they serve and it only remains for a united public opinion to indose those optimistic men who are risking capital for public welfare.

Studies in High Tension Transmission

In our last issue brief allusion was made editorially, to the rapid advance in the use of high voltages for the electric transmission of energy.

It is interesting to summarize the experiences of three companies that have used 100,000 volts or over for a number of months and which were reported upon in detail at the recent Chicago convention of the A. I. E. E. The plants of these companies are situated in widely separated portions of the country; namely, the Great Western Power Co. has its plant in California; the Great Falls Power Co. in Montana, and the Southern Power Co. in Northern Carolina. All three use overhead grounded wires and string their power lines upon towers varying in distance from over 600 ft. in level country to over half a mile over hilly country or water channels. Both stranded copper and aluminum are in successful operation. Two plants have been subjected to frequent lightning storms and in neither case has serious damage happened. In fact, a total shutdown of 39 minutes is the summary for eighteen months operation. The charging current in each case very nearly agrees with the computed currents, thus showing that mathematical processes can definitely foretell results of this nature. The suspension type of insulator seems to be the favorite, no serious trouble from either swinging of insulators or conductors having arisen. The question of opening the high tension side appears to have no more difficulty attached to it than those of much less voltages. The wind and sleet seem to have caused but little trouble. One plant reports that in a sixty mile per hour wind storm, it is their opinion that the wires of their transmission system will all sway sideways at approximately a similar angle of about 40 degrees and thus no trouble will be experienced one with another. Those presupposing corona effects from such high voltages found their prophecies unsubstantiated. The plant manager reporting the greatest corona effect states that this practically disappeared after three weeks' operation and accounts for its disappearance as being due to the rough points in stringing the wires having either been blunted or worn off during this period of service. The question of interference of telephone wires seems to have been properly handled.

At the same meeting of the A. I. E. E. above reported, the data collected from an exhaustive set of tests on the law of the corona and the dielectric strength of air were presented. It may well be stated that the laws of this hitherto uncertain phenomena have been finally and successfully solved for all practical purposes. Briefly, the corona losses have been found to be proportional to the frequency, to the square of the excess voltage above the disruptive critical voltage, to the square root of the conductor radius and inversely proportional to the square root of the conductor distance. It is found that atmospheric conditions have an influence also upon this loss; namely, smoke, fog, sleet, rain storms and snow storms lower the critical voltage and increase the loss, the effect of snow being greater than that of any other weather conditions. Humidity or "vapor products" have no effect on either critical voltage or the loss, while heavy wind has no effect on either at ordinary commercial frequencies.

It is difficult to say whether conditions in the near future will warrant even higher voltages and as to what the outcome of such an advance might be. This is certain, however, that present experience clearly demonstrates that voltages up to 100,000 are eminently practical.

Freight Traffic of the Interurban

It is interesting to note the ever increasing demands upon interurban electric service. Aside from bringing the people of the rural districts one step nearer to the pulsating life of the city, it aids wonderfully in the way of assuring rapid and cheap transportation of fruits and other farm products of a perishable nature. In the thickly populated regions of the Middle West this means of ready transportation of fruits has proven of wonderful service in the securing of maximum good results.

In order that fruit may bring the best prices it must be laid down in the heart of the fruit market comparatively fresh, be neat and attractive in appearance, and possess delicious flavor and other natural characteristics. Transportation by water is excellent when the same is of ready access, for the water, by cooling the atmosphere lowers the temperature some degrees, as a rule, and at the same time this mode of transportation is free from dirt and dust. But it is only in a few favored localities that water transportation is practicable. Unquestionably the next best mode is the electric interurban service. As an example of the many fruit-carrying interurban roads may be mentioned the Northern Electric Railway Company, operating between Chico and Sacramento, with about 100 miles of road, its entire length passing through a region almost exclusively given to fruit growing and farm products. This road has operated cars for the exclusive handling of fruit for the past four years and although at the time of starting the service this class of business was of a small extent, it has grown until today the revenue derived from this business helps considerably to swell the net income of the company. Success in this case is due not only to the fact that the farmer recognizes the value to be derived from shipping his fruit in this manner, but partly from the fact that the company has treated the small shipper exactly like the larger. If a man has but one case of fruit to be shipped he is shown the same consideration as the man who has a hundred. Under the system just cited one of the best evidences of the value of this service to the growers is shown by the fact that land readily accessible to the interurban has increased in value during the past few years about 30 per cent, while land at a distance has advanced comparatively little.

Many illustrations might also be cited from other interurban systems of the Pacific Slope which represent such an aggressive factor in our rapid growth. The opening of the Panama Canal will add much to our material prosperity. Our interurban systems will assure rapid transits of fruits to the Coast cities. Thence by water, the great markets of the world will be easily accessible. Such opportunities before us for commercial development we can hardly estimate!

PERSONALS.

Thomas Mirk of the firm of Hunt, Mirk & Co., is enjoying an outing at Lake Tahoe.

K. G. Dunn, of Hunt, Mirk & Co., has returned to San Francisco, after a trip to Denver.

J. M. Berkley, with the Edison Electric Company of Los Angeles, was at San Francisco last week.

John M. Gardiner, a veteran electric railway man of Los Angeles, was at San Francisco last week.

H. R. Noack, general manager of Pierson, Roeding & Co., has returned to his San Francisco office after visiting Denver on business.

R. D. Holabird, president of the Holabird-Reynolds Company, recently returned to San Francisco after spending a vacation at Lake Tahoe.

E. I. Pratt, advertising manager for the Kellogg Switch-Board & Supply Co., has returned to Chicago from a brief trip to the Pacific Coast.

H. L. Middleton of Boulder Creek, who has electric lighting interests in the Santa Cruz mountains, was a San Francisco visitor during the past week.

S. N. Griffith of Fresno, who has been prominently identified with the promotion and construction of electric railroads at Fresno, was a recent San Francisco visitor.

F. B. Gleason, Pacific Coast manager for the Western Electric Company is expected to return to his San Francisco office this week from a trip through the Northwest.

F. W. Cox, of Carson, Nev., has arrived at San Francisco en route to the Orient, where he expects to take charge of the agency for a large American electric manufacturing company.

M. C. Miller, assistant to the president of the Allis-Chalmers Company, returned to Milwaukee last week after visiting Fred L. Webster, the Pacific Coast manager, at San Francisco.

E. B. Spaulding, salesman with the engineering and contractors' department of the San Francisco office of H. W. Johns-Manville Co., is spending a month's vecation at Sioux City, Iowa.

F. O. Sievers, salesman with the Fort Wayne Electric Works, of the General Electric Co., is covering Southern California. J. A. Herr, of the Sprague Electric sales force is in the same territory on a business trip.

R. H. Fenkhausen, who for the past six years has been chief electrician at the Risdon Iron & Locomotive Works, entered the service of the Union Iron Works Company of San Francisco as electrical engineer, beginning July 1st.

The Oregon State Board of Health has appointed Louis C. Kelsey of Portland, Ore., consulting engineer to advise the Board in matters relating to municipal water supply and sewerage construction, including methods for sanitary disposal of sewage.

H. H. Noble, president of the Northern California Power Company, has just returned from a trip to the Coleman hydro-electric plant which is nearing completion. It is probable that current from this new development will be available early in August.

G. R. Milford, who has general supervision of hydro-electric construction work on the Northern California Power Company's system, visited the San Francisco office last week and is now making an observation tour of various power plants in the State of California.

C. L. Harriman, an official of Chicago Street Railway lines, was a San Francisco visitor during the past week.

Louis C. Kelsey, Selling building, Portland, Ore., has been employed by the City of Gladstone, Ore., as engineer to prepare specifications, plans, estimates, etc., for a pumping plant and waterworks system. An election to vote $20,000 bonds for construction will be held July 31st.

G. A. Schneider, sales engineer with the San Francisco office of the Western Electric Company, recently returned from the annual conference of power apparatus specialists at New York City and nearby factories. During his return he attended the A. I. E. E. meeting at Chicago, and visited the company's offices at Chicago and Omaha.

F. L. McNally, district commercial superintendent of the Pacific Telephone and Telegraph Company, has been promoted and transferred to the Seattle district. The change caused several other promotions, District Superintendent F. F. De Lury, formerly at the head of the Oakland district, having taken McNally's place at San Francisco, and having been succeeded in turn, at Oakland, by H. C. Brownlee, the former commercial manager at that point. Maynard Bailey, formerly commercial manager at Berkeley, has been given the same position at Oakland, and B. A. Glover, the former contract agent of the Oakland district, has been made commercial manager at Berkeley.

NEW BULLETINS.

A unique bulletin has just been published by the Bridgeport Brass Company, entitled the "Line of Long Life." The bulletin sets forth the claims of "Phono-Electric" trolley wire in a very pithy yet attractive manner.

The Welsbach Company of Gloucester, New Jersey, have just published a new bulletin on "Filament Ignition of Gas." The paper is edited by the experimental engineering department of the Welsbach Company. In a logical sequence is reviewed filament ignition of gas by small platinum wire and giving finally a detailed description of the new ignition process now being put on the market by the company. The paper is both useful and instructive.

TRADE NOTES.

Contracts for tunnel work on the Oakland-Antioch electric road are being received at the local office of J. G. White & Co., 103 Edith St., Oakland, Cal.

A unique electric chocolate warmer is described in a pamphlet from the Cutler-Hammer Mfg. Co., Otis & Squires, of San Francisco being Pacific Coast agents.

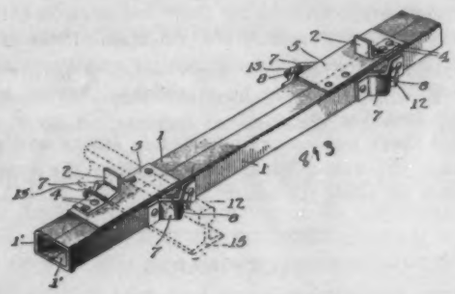
The Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has received an order from the Oakland Traction Company, Oakland, Cal., for ten equipments of type HL (non-automatic) unit switch control.

The Fort Wayne Electric Works has sold to the Granite Gravel Company, San Francisco, a 125-h.p. induction motor for a gravel haulage engine, including swivel base, for use at Livermore. Also a 125-h.p. motor which will be direct-connected to a duplicate gravel hoist, built by the United Iron Works of Oakland for the same company.

The General Electric Company has sold to the Northwestern Pacific Railway Company a 500-kw., 3-bearing motor-generator set rated as follows: One A.T.I. 10, 660-k.v.a., 720-r.p.m., 2200-v., synchronous motor mounted on the same base with and direct-connected to one M.P.C. 4, 500-v., 600-v./600-v., compound wound railway generator with direct-connected exciter.

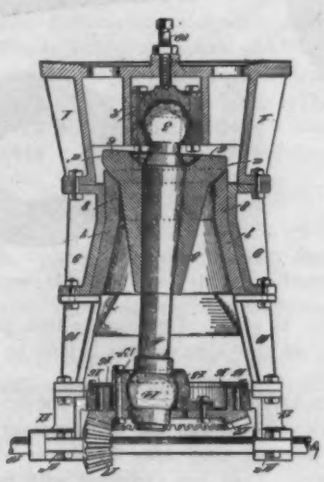
PATENTS

997,893. Metallic Railroad Tie. Oscar W. Beach, Los Angeles, Cal. A metallic railroad tie comprising two channel members extending side by side with their channels placed together forming a hollow tie, means clamping said channel



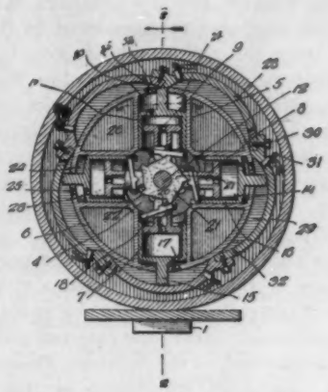
members together, said channel members being provided with lugs for engagement with the rail, and blocks within said channel members filling the same at portions adjacent to said lugs to form a reinforced support beneath the rail, and sound deadening filling in said blocks.

997,918. Rock-Crusher. Adolph W. Jones, Oakland, Cal. The combination in a gyratory crusher, of exterior dies, and interior coacting shoes, a shaft upon which said shoes are carried, a ball in which the lower end of the shaft is stepped, a globular socket in which said ball is turnable, a corre-



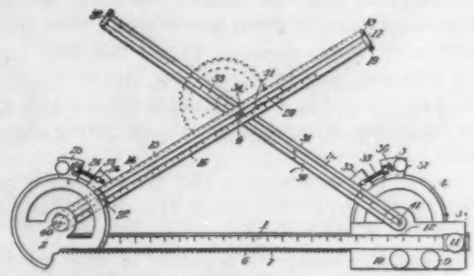
sponding ball and socket support for the upper end of the shaft, a horizontally turnable driving gear to which said ball and socket bearing is eccentrically connected, and means whereby the bearing is adjustable on the gear to vary the radius of gyration of the shaft.

997,824. Rotary Internal-Combustion Engine. Jacob Jacobsen, San Francisco, Cal. A rotary engine of the internal combustion type comprising a rotary shaft, a stationary member provided with a plurality of radially disposed cylinders, plungers fixedly supported at the inner ends of the cylinders and a circular rim connecting the outer ends of the cylinders, a rotary member fastened to said shaft and comprising a plurality of combustion chambers, and pistons arranged to operate in said cylinders and provided with abutments to op-



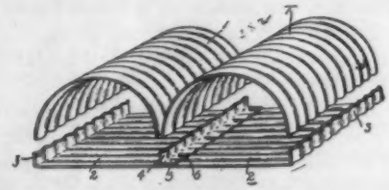
erate through said circular rim across the space of the combustion chamber in successive order.

997,826. Surveying Instrument. Paul Jones, Ontario, Ore., assignor of one-third to A. N. Soliss, Ontario, Ore. The combination of a base member, of a protractor secured at one end of said base member, a side member pivoted to said protractor, the pivotal bearing of said side member having an opening formed therethrough, a slide carried by said base



member, a protractor connected with said slide, a second side member pivoted to said slide, the pivotal bearing of said second side member having an opening formed therethrough, and means for pivotally connecting said side members, the pivotal bearing of said connecting means having an opening formed therethrough.

997,382. Culvert Structure. Charles A. Foster, Portland, Ore. A culvert structure comprising a base plate having up-turned side flanges and an up-turned intermediate flange, and



a pair of arched top members adapted each to engage said intermediate flange and one of said side flanges.

INDUSTRIAL

WESTERN ELECTRIC PROGRESS ON THE PACIFIC COAST

BY G. A. SCHNEIDER.

Of the modern electrical supply houses on the Pacific Coast that of the Western Electric Company at San Francisco is the largest, and may also be considered as the oldest, as it was developed from the California Electrical Works, which was the first electrical supply house in the West.

Historically, this original company dates from 1877, when it was incorporated as the California Electrical Works, in which was consolidated the Electrical Construction and Maintenance Company—organized in 1868—The California Electric Power Company, the Pacific Electro-Depositing Works and the California Electric Gas Light Company.

In 1892 the California Electrical Works became identified with the interests of the Western Electric Company of Chicago, acting as Pacific Coast agents for the latter concern. The business continued under the original name until May, 1908, when it was changed to the Western Electric Company.

The offices and main warehouse of this company are located on the north side of Folsom street, at Hawthorne street, a small thoroughfare running parallel with and between Second and Third streets. The building consists of three sections, each of four stories, covering a ground area of about 300 by 150 feet and having 110,000 square feet of floor space. Certain sections of the building are used for warehouse purposes, another for manufacturing or shop purposes, while the fourth floor contains the offices of the company.

In laying out the building special care was taken to design it with due regard for safety from fire, with the result that the entire premises are of mill type construction, with walls of brick faced with red pressed brick, and the windows of wireglass throughout, all features being in accord with the fire underwriters' requirements. Under the rear courtyard there is a reservoir having a capacity of 120,000 gallons of water, while on the roof is a 50,000-gallon tank, which supplies water for numerous automatic sprinklers placed throughout the building.

The logic of this construction and fire protection was well proven during the great fire, when the entire building was saved.

To conduct the enormous business of this company, at San Francisco, requires a large investment and the services of from 250 to 300 people. A large portion of the investment covers the heavy stock of supplies, telephone apparatus, cable and power apparatus regularly kept on hand.

In addition to the building just described, the company maintain a large warehouse at Emeryville, California. Here they have available about 56,000 square feet of floor space in the building and 160,000 square feet of space in the surrounding yards, in which cable, poles and material of a similar nature are stored.

The company also have a pole yard at Weco, California, covering approximately fifteen acres. At this point a large and varied stock of poles—usually about 20,000 in number—are kept. This site was chosen as a storage yard on account of facilities afforded for handling boat shipments, all of the poles being shipped from the forests in Washington and Oregon in this manner.

A better idea of the volume of material handled by these warehouses may be gained from the statement that within the last year 301 full carloads of supplies were handled. This does not include the pole shipments received at Weco.

This well-selected stock is supplemented by a complete manufacturing plant on the third floor of the Folsom street building, enabling the company to assemble certain lines of apparatus to meet special requirements. This applies particularly to telephone switchboards and apparatus, and in these shops many of the private exchange boards used on the Pacific Coast are assembled. Ample facilities are also provided for all kinds of repairs and telephone and telegraph apparatus.

To further properly care for their business on this Coast, the Western Electric Company also maintain offices and warehouses at Los Angeles, Oakland, Seattle and Portland. The latter house is the latest to be established, having been put in operation last August.

Each of these houses carry complete stocks and are conducted along the same lines, thus insuring the same high-grade service all along the coast.

TROLLEY HARPS.

The Ohio Brass Company of Mansfield, Ohio, is listing a new design of trolley harp for which several commendable features are claimed.

The harps are so designed as to eliminate all sharp corners or projections which would be liable to catch in the overhead. Great strength has been obtained with light weight.

Clever Design of Trolley Harp with Phosphor Bronze Contacts

The body casting is made of malleable iron and is provided with a rope hole on each side so that it may be reversed when one side is worn.

The contact springs are made of phosphor bronze and are held in place without the use of any rivets or other fastening devices so that they may be easily and quickly renewed when worn. They are provided with reversible wearing washers which may be worn on both sides before renewal is necessary.

TRADE NOTES.

The San Francisco, Oakland & San Jose R. R. Co., San Francisco, Cal., has recently placed an order with the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., for 25 double equipments of No. 302 railway motors and type M control.

The General Electric Company recently sold to the Pacific Gas and Electric Company a 2-unit, 2-bearing, reversible, motor-generator set, consisting of one M.P.C., 8-pole, 1000-kw., 514-r.p.m., 550/600-v., compound wound, d.c. generator with commutating poles, direct-connected to one A.T.I., 14-pole, 1120-kw., 4000/2300-v., synchronous motor.

NEWS NOTES

FINANCIAL.

SALEM, ORE.—Articles of increase of capital stock have been filed with the Secretary of State by the H. M. Byllesby Company of New Jersey, increased to $6,000,000.

VANCOUVER, WASH.—The local plant of the Portland Railway, Light and Power Company, which was recently destroyed by fire, is to be rebuilt at a cost of $65,000.

SAN DIEGO, CAL.—Work which will cost the San Diego Consolidated Gas and Electric Company about $75,000 will begin as soon as material for underground wire conduits is received.

OROVILLE, CAL.—That the Sacramento Valley Power Company is planning an extension of its system to Oroville, as well as to other valley cities, became apparent when news reached Oroville that the company had mortgaged its holdings for $2,000,000.

FRESNO, CAL.—At the last meeting of the board of directors of the Fresno, Hanford and Summit Lake Railroad Company, all the debts of the company, contracted before the money for the building of the road was secured from the Guaranty Trust Company of New York, were liquidated. The total expenditures for these obligations amounted to $16,000.

REDDING, CAL.—It is learned that the $2,000,000 mortgage deed of trust by the Sacramento Valley Power Company, which was given for the purpose of taking up $400,000 of bonds of subsidiary companies, $600,000 will be used for enlarging the company's plants and extending its lines and $1,000,000 will be held in reserve. This company is a combination of three older companies, the Sacramento Power Company, the Shasta Power Company and the Northern Light and Power Company. It has two power plants near Lassen Peak, each with a capacity of 2000 h.p. These will be increased to 7000 h.p. each. The company's transmission lines are to be extended to Willows and to a connection with the lines of the Great Western Power Company, from which it will buy additional power as needed. The Great Western is now under the management of the Fleishhacker interests, and the Sacramento Power Company is controlled by the same parties. Mortimer Fleishhacker is president of the latter; Tilden Tognazzini, vice-president; Samuel Napthaly, general manager, and A. W. Smith field manager. It is understood that with its own output and its supply from the Great Western, the Sacramento Valley Power Company will distribute in the neighborhood of 40,000 h.p. It will cover the field from Chico north to Redding.

INCORPORATIONS.

JACKSON, CAL.—Articles of incorporation of the Mokelumne River Power Company have been filed with the County Clerk.

OAKESDALE, WASH.—The Oakesdale Home Telephone Company has been organized with $10,000 capital. A. Woodward and Ed Roberts are among the trustees.

SAN FRANCISCO, CAL.—The California Consolidated Light and Power Company has been incorporated with a capital stock of $5,000,000 by C. S. Goodrich, J. T. Pigott, T. E. Palmer, Grover O'Connor and G. R. Ray.

SAN FRANCISCO, CAL.—The Somerset Mutual Water Company has been incorporated with a capital stock of $60,000; subscribed, $900. The directors are A. F. Jelinck, W. J. McGimpsey, W. C. Emerick, R. F. Hammond, J. E. Cohn, C. W. McKee, A. H. Drum, G. W. King, B. A. Guernsey.

SAN JOSE, CAL.—A copy of the articles of the Union Water Company of California has been filed here by Pillsbury, Madison & Sutro of San Francisco, attorneys for the concern. The company is incorporated for $5,000,000, to carry on a general business of a public service corporation. There are 500,000 shares of the capital stock, 300,000 of which are common and 200,000 preferred. The stock so far actually subscribed has been 50 shares of the common stock at $10 a share, and this stock is held in equal proportion by each of five directors—Wm. T. Barnett of Berkeley, Alfred D. Plaw of Oakland, Platt Kent and V. W. Vincent of San Francisco, and F. D. Madison of San Rafael. Their place of principal business is San Francisco, and the articles of incorporation were issued by the Secretary of State December 21st last.

ILLUMINATION.

LOS ANGELES, CAL.—The Guy M. Rush Company, which is developing Lawndale, expects to have a first-class electric lighting system in the very near future.

SEATTLE, WASH.—A bill has been passed authorizing the city engineer to expend the sum of $20,000 for surveying the new Cedar River water shed and the sum of $400,000 for the new dam.

TRANSMISSION.

LEAVENWORTH, WASH.—The Council has granted to the Washington Steel and Iron Company a franchise to construct and maintain a transmission line in the town of Leavenworth.

AUBURN, CAL.—The Board of Supervisors has granted to the Great Western Power Company a franchise to erect and operate a transmission line upon the roads of the county of Placer.

LOS ANGELES, CAL.—A franchise has been granted to the Pacific Light and Power Company for a power line to be installed in the foothills district east of city limits of Los Angeles and extending to Pomona.

TUCSON, ARIZ.—H. A. Smith has taken steps towards the establishment of a big power and irrigation project near Noria, Sonora, which will furnish power to four mines and smelters and the town of Llano and water for irrigation of 15,000 acres.

VALLEJO, CAL.—The Pacific Portland Cement Company has made application to the Board of Supervisors for a franchise to erect and maintain poles and wires for the transmitting of electric light, heat and power upon certain highways in Solano County.

SAN FRANCISCO, CAL.—To supply a great part of the lower end of the San Joaquin Valley, especially the West Side oil fields, with power, the San Joaquin Light and Power Company expects to turn on the current in the big Bakersfield main line this week. With three small ends of the big work of installing this line and all the connected sub-stations yet to be done, it is believed the wire will be carrying its full 60,000 volts in a few days. Over on the West Side, where the main line runs, there are now five miles open between the ends of the wires. These five miles are being held open to wait for insulating. As soon as this arrives, the line can be connected up with little effort. The control station for this

line, which is located at Fresno Copper Mines, northeast of Clovis, is finished except for some of the connections which will be the last part of the job done. This wire, with its capacity of 40,000 volts, is to be the highest power line in the field here. The company is now commencing on the survey for the Dos Palos, Los Banos and Gustine line. This work will be through very shortly, because of the easy country traversed by most of the line, and the delivery of poles will begin at once. Up at Crane Valley the job will keep the people busy until along in August, because hand placing of riprap work in the dam has to be done, and this is the slowest part of the entire job. In the power house only five more heavy pieces have to be placed, and these will be in within a week. McKittrick is now being wired with the intention of getting the current for lighting and other purposes there by the middle of July. Work on the sub-station there is progressing well. Light is also to be furnished to several places in Reward.

TRANSPORTATION.

PASADENA, CAL.—Work will start in a short time electrolizing the Southern Pacific tracks from the station at Colorado street, Broadway to Bellevue drive.

SAN BERNARDINO, CAL.—The application for a franchise for an electric line through the streets of the city, applied for by F. A. Worthley, has been ordered advertised for sale.

BOISE, IDAHO.—Considerable local interest attaches to the surveying of a line for an electric railway between Nampa and Caldwell by surveyors in the employ of Walter Sebree of Caldwell.

CHICO, CAL.—The Northern Electric Railway Company has made application for a franchise to operate a railroad of standard gauge with single or double tracks in the streets of the city of Chico.

SAN BERNARDINO, CAL.—Plans for a right of way from Urbita Springs to Colton have been formulated by the Chamber of Commerce. The Pacific Electric has advised immediate construction and its ultimate connection with Riverside extension to Highgrover as soon as the right of way is secured.

SACRAMENTO, CAL.—An application for a franchise to extend the street car system through the suburbs to the east and southeast of the city, making several loops, was made to the Board of Supervisors this week by the Sacramento Electric, Gas and Railway Company. The application covers three sections of single or double tracks as the company may hereafter decide.

PORTERVILLE, CAL.—In anticipation of the construction of the main power plant of the Tulare County Power Company, officers of the company are now securing rights of way for an electrical railroad line which will connect Porterville with Lindsay on the north and Tulare on the west and which will tap the entire orange and dairy district of eastern Tulare County.

TELEPHONE AND TELEGRAPH.

ASTORIA, ORE.—The Nehalem Valley Company has been incorporated and will operate and construct telephone lines.

CENTRALIA, CAL.—The Hanaford Skookum Telephone Company of Centralia has been incorporated for $1500 by A. Bannse and W. Eshon.

TACOMA, WASH.—The Sunset Telephone Company has awarded a contract to Westerfield & Van Buskirk of this city for the erection of their sub-station on Seventh and Proctor streets at a cost of $25,000. They will also erect another station in the south end of the city.

EUGENE, ORE.—The government will construct 35 miles of phones in the forest district, also a branch line from Box Canyon to Waldo Lake.

WINONA, WASH.—The farmers north of this town are building a telephone line into their country to connect with the Winona system at the Muir place.

DAVENPORT, WASH.—W. N. Purdy, manager of the Washington Consolidated Telephone Co., has about completed a survey between this place, Fruitland and Hunters for the installation of a toll line.

KALANA, WASH.—The Mt. Pleasant Telephone Company has presented the County Commissioners of Cowlitz County a petition asking for a franchise to erect a telephone line over certain streets in said county.

SAND POINT, IDAHO.—Le Roy H. Whitcomb has been granted a franchise to maintain poles and wires on the streets of Clarksfork for the purpose of supplying the public with communication, for a period of 50 years.

MARSHFIELD, ORE.—The franchise held by J. M. Blake for the construction of an electric car line has been forfeited, on account of not complying with the specifications, which stated that he should have one mile of track completed by July 1.

RENO, NEV.—A number of Reno men are now working toward a plan to bring the Home Telephone Company into Reno to compete with the Pacific Telephone and Telegraph Company. The agent of the Home company has been in Reno for some time.

VANCOUVER, B. C.—The British Columbia Telephone Company has made application to the Governor in council for authority to construct an aerial wire crossing over the Fraser River from a point at the westerly end of Choam Slough to the south bank of the river.

WATERWORKS.

BAKERSFIELD, CAL.—The Electric Water Company will put in a plant in East Bakersfield capable of supplying that part of the city with water.

PORTERVILLE, CAL.—The $60,000 bond issue has been carried by a large vote; $43,000 was voted for waterworks and $13,000 for street improvements.

LOS ANGELES, CAL.—An ordinance has been adopted granting to Samuel M. Walker a franchise for a water system in certain portions of Los Angeles County.

SAN DIEGO, CAL.—An assessment has been levied on the stock of the Escondido Mutual Water Company to replace the wooden flumes with cement ditches and tunnels.

NOGALES, ARIZ.—An election is to be called for Nogales to vote on an issue of $100,000 bonds for a water system and $60,000 for a sewer system, the election to be held August 10th.

MEDFORD, ORE.—The Council has resolved to lay a 6-inch water main on Roosevelt avenue, protests against which will be heard on the 18th of July at the Council chambers in the City Hall.

HERMISTON, ORE.—An election will be held August 7th to decide on a $25,000 bond election for the construction of a municipal water system. Bonds for $4000 will also be voted for a city park.

MARSHFIELD, ORE.—Thos. P. Nolan, an attorney, of Omaha, has completed negotiations for the purchase of the Coos Bay Water Company from Flanagan & Bennett. He has applied for a franchise to construct a water system in the city of Marshfield.